The MINING CONGRESS JOURNAL

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In This Issue

Solving Ventilation Problems by Mechanical Means
Mechanical Ventilation at Minas de Matahambre
Stoping Methods in Michigan Copper Lodes

Safety First—More Than a Slogan
Experiment Station Division, U. S. Bureau of Mines
Hazards in Connection with Concentrated Mining

Permissible Powders Where No Explosive Gas?
Selection of Explosives for Coal Mining
Importance of Equalization in Locomotive Design

FIFTH ANNUAL COAL CONVENTION
Proceedings Covering:
Management and Safety Problems
Power
Transportation
Coal Cleaning

The Mechanization Survey
Legislative Review

Contributors:

Frank H. Probert, A. C. Fieldner, D. Harrington, Charles A. Mitke, George L. Richert, Albert Mendelsohn, T. W. Guy, Robert Schless, William A. Austin, G. B. Southward, H. S. Gilbertson, H. A. Treadwell, Charles Enzian, J. E. Jones, Richard D. Maize, C. E. Watts, R. L. Adams, R. M. Fleming, J. T. Jennings, W. C. Shunk, Thos. Fraser, E. J. Newbaker, R. G. Perry, C. P. Anderson, J. B. Morrow, B. C. Osler, G. P. Bartholomew. Thomas F. Steele, Eli T. Conner.

Proved by fire

To THE eye, the carbon brush seems a simple thing. Just a block of carbon ground down to the right shape and size, sometimes with a shunt attached. From mere inspection, no one would suspect how complicated its history really is. A perfectly operating brush may, at the most, suggest that a high degree of technical skill was involved in the selection of that particular brush for the work it has to do.

Yet as a matter of fact that technical skill goes far back of mere selection. No less than 36 major operations are necessary to make National Pyramid Brushes. The number varies somewhat with different types of brushes, and may go as high as 49, from the burning of the oil into lampblack to the last test and inspection of the finished product.

Probably the most unexpected manufacturing process is that of baking. There are two baking operations, totaling 60 to 66 days in ovens and furnaces of high temperatures. The simple-looking carbon brush is in fact as highly developed technically as are the machines on which it is used.

NATIONAL CARBON COMPANY, INC.

Unit of Union Carbide UCC *and Carbon Corporation*

Carbon Sales Division

Cleveland, Ohio — SILVER STRAND CABLE TRADE MARK REGISTERED — San Francisco, Cal.

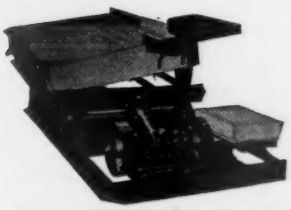
Branch Offices and Factories

CHICAGO, ILL. PITTSBURGH, PA. NEW YORK, N. Y. BIRMINGHAM, ALA.

Pump End View of Menzies Installation in Our Testing Plant

Making Greater Profits

THAT is the unanimous report from users of Menzies Hydro Separators and Arms Air Concentrating Tables. The combination of these two units, one wet process and the other dry process, ideal for cleaning all size coals, offers you the many advantages of minimum maintenance and labor required—low power consumption—few wearing parts—maximum efficiency—thoroughly cleaned coal—and a quick return on your initial investment.



The Arms Air Concentrating Table is of light, rugged construction. Its operation is that of subjecting a bed of coal to an upward moving current of air to stratify the bed, at the same time conveying the bed with a reciprocating action, moving the refuse off the end of the table, and the clean coal off the lower side. It is ideally applied to cleaning of fine size coals.

When you contemplate the installation of coal cleaning equipment, it will profit you to consult our engineers. We will send you a Menzies Hydro Separator or an Arms Air Concentrating Table, or both, so that you may run tests in your own plant—or better still, we will run complete tests of your coal at our plant at Harvey, Illinois, with complete laboratory results, so as to allow you the benefit of the vast experience of this Testing Department. The service, of course, implies no obligation.

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COAL TIPPLES AND CLEANING PLANTS
ARMS CONCENTRATING TABLES AND SCREENS

The MINING CONGRESS JOURNAL

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METALS

Solving Ventilation Problems by Mechanical Means

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Stoping Methods in Michigan Copper Lodes

COAL

Are Permissible Powders Needed Where Explosive Gas Is Absent

Selection of Explosives For Coal Mining

Importance of Equalization in Locomotive Design

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"Blue Center" Steel Wire Rope

—upholds the honor of a great name. For more than three-quarters of a century the name Roebling has represented all that is best in wire rope and wire.

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Write for catalog A-545

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Jeffrey Arcwalls and Bottom in

Jeffrey 29-C Arcwall with offset cutter bar cutting on the bottom, "necking" out a room.

Jeffrey 29-C Arcwall cutting top in 36" coal

The Jeffrey Manufacturing Company

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JEFFREY

Cutting Top Low Coal

Jeffrey 29-C Arcwalls are developing new mines at Red Jacket, West Virginia, making twenty cuts per shift in coal from thirty-six to thirty-eight inches high.

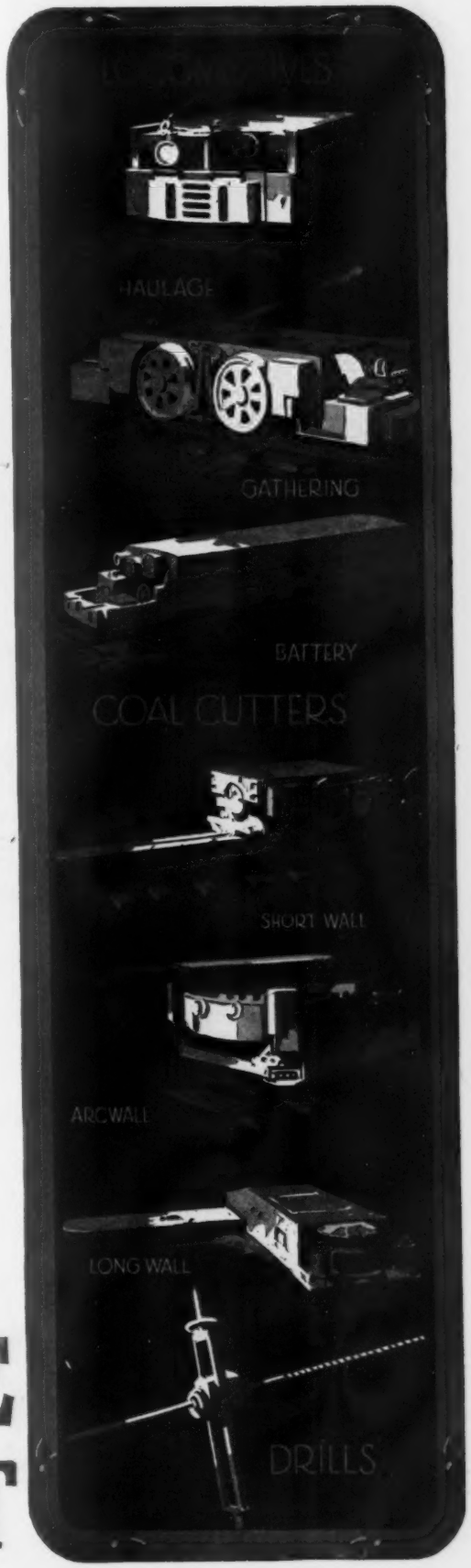
Both top and bottom cutters are used to meet varying roof conditions. Where the roof is strong the Jeffrey 29-C with the offset cutter bar undercuts the seam on the bottom, leaving no coal to be taken up by the loaders.

Under a weak roof the top-cutting Jeffrey Arcwall is used, cutting a five-and-one-half inch kerf and leaving the roof undamaged.

The cutter bar on the 29-C can be tilted readily to either side by the three motor-driven jackscrews in the frame. An irregular seam is easily followed and the cutter bar can be fed around impurities when it is not expedient to cut through them.

Jeffrey Arcwalls are also used for slabbing on a long face, or taking out a band of dirt or rock. While cutting above or below a rock band, the return swing of the cutter bar will knock most of the rock out of the cut.

Send for Catalog No. 406-C describing Jeffrey Arcwall Coal Cutters.



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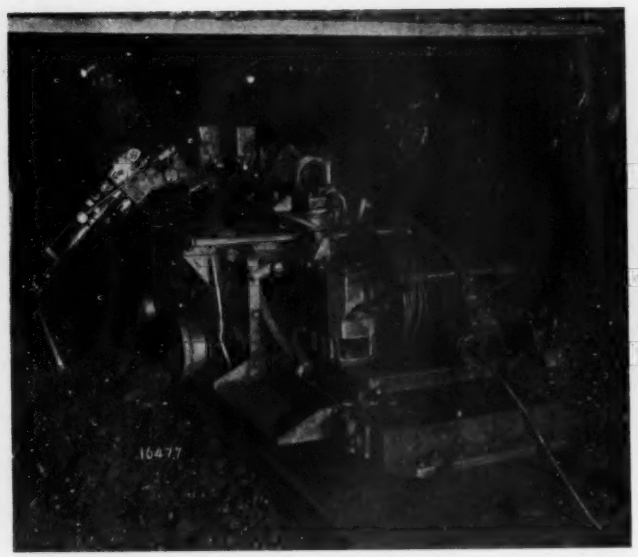
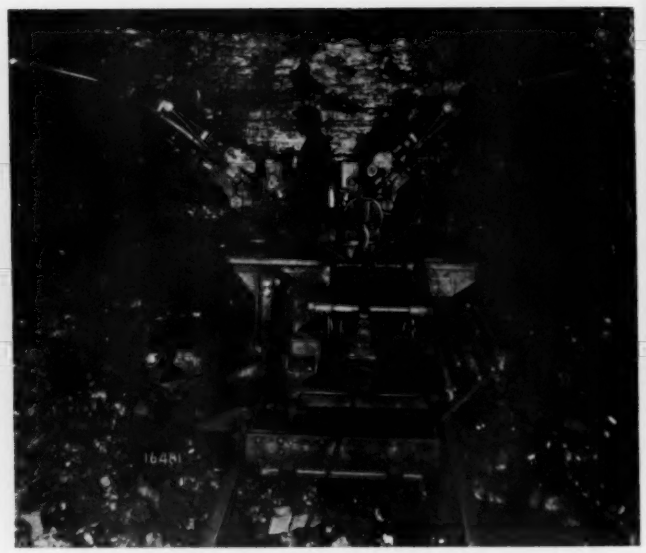
COAL MINE EQUIPMENT

The New 56-A Drills Any Bottom and Top Without





Drilling at the Bottom

BY drilling two holes simultaneously and tramming from room to room under its own power, the Jeffrey 56-A Drilling Machine cuts down drilling time and tonnage costs.

A fair average of the machine's drilling capacity is fifteen holes per hour, including tramming time. The number of holes per room and the distance between the rooms will increase or lessen this number.

The 56-A Drilling Machine accomplishes the work rapidly, as there are two drills each mounted on independent arms and turn-tables so that the drills can be put in place quickly. Each drill is driven by a 3-H.P. motor, which

Drilling Near the Roof

motor is also used for raising and lowering the drill, thus eliminating all lifting and heavy work. The turn-tables and arms are so arranged that the drills are locked rigidly in position. No jacks or external anchors are used.

Besides the two motors for the augers, a third motor, 13-H.P., drives all four truck wheels and allows the truck to tram with a speed up to six miles per hour.

The Jeffrey 56-A can drill anywhere between roof and bottom. With full load, the forward feed of the augers is thirty-six inches per minute.

The advantages of the 56-A over the unit type

Branch Offices: New York Pittsburgh Scranton, Pa. Philadelphia Chicago Birmingham
Sales and Service Stations: Birmingham, 26 South 20th St. Winchester, Ky., 122 N. Main St. Salt Lake City, 158 W. Second South St.

JEFFREY

where Between Leaving Track

Tramming

are: first, two men can drill two holes at the same time instead of one; second, no time is lost in unloading drills, setting them up, taking them down, or loading them back on a truck; third, the drilling machine trams as fast as a gathering locomotive and does not slow up traffic; and fourth, it will drill holes close to and parallel with top and rib. In many mines this is very important, as with ordinary drilling machines the drill hole is apt to run up into the roof.

We shall be glad to send you a complete description together with photographs of the 56-A.

The Jeffrey Manufacturing Company

958-99 North Fourth St., Columbus, Ohio

Denver · Charleston, W. Va. Salt Lake City Montreal, Canada
Pittsburgh, 600 Second Ave. Scranton, 122 Adams Ave. Terre Haute, Ind., 319 Cherry St.

COAL MINE EQUIPMENT

Reports From the Field

New Explosives Saving 11% to 15%

AT a cement company's limestone mine in western Pennsylvania, Hercomite 4 has replaced 40% Extra L. F. Gelatin. Performance and fumes are as good as with Gelatin. The saving on explosives amounted to 1½ cents per ton of stone mined, or over 11%.

A large iron mine in Minnesota has adopted Hercomite 3 in place of 50% Extra L. F. dynamite; and at another similar mine Hercomite 4 has replaced 40% Extra L. F. dynamite. In each instance performance and fumes were satisfactory and the saving was over 15%.

HERCOMITE 2 is nearest grade to	60% Extra L. F. or 40% to 50% Gelatins
HERCOMITE 3 is nearest grade to	50% Extra L. F. or 30% to 35% Gelatins
HERCOMITE 4 is nearest grade to	40% Extra L. F. or 25% to 30% Gelatins
HERCOMITE 5 is nearest grade to	30% Extra L. F.
HERCOMITE 6 is nearest grade to	25% Extra L. F.
HERCOMITE 7 is nearest grade to	20% Extra L. F.

HERCOMITES 2 to 7, that are reducing costs wherever they are introduced, should not be confused with the regular Extra and Extra L. F. grades. They replace these grades as well as the Extra L. F. Gelatins, because they represent the greatest explosives value we have ever offered.

Cartridge counts in 1¼″ x 8″ size range from 240 for Hercomite 2 to 350 for Hercomite 7 per 100 pounds. The strength of 100 pounds of explosive is the same for all of the Hercomites in the series, but because of the different cartridge counts to the 100 pounds for each of the different powders the cartridge strength runs from 20% in Hercomite 7 to 50% in Hercomite 2. And the cost per cartridge is the lowest ever offered the trade for equal explosive value.

Write for prices and booklet.

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934 King Street, Wilmington, Delaware

Please send me additional information regarding the new Hercomites, No. 2 to No. 7.

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Company _____

Street _____ **City** _____ **State** _____

1521

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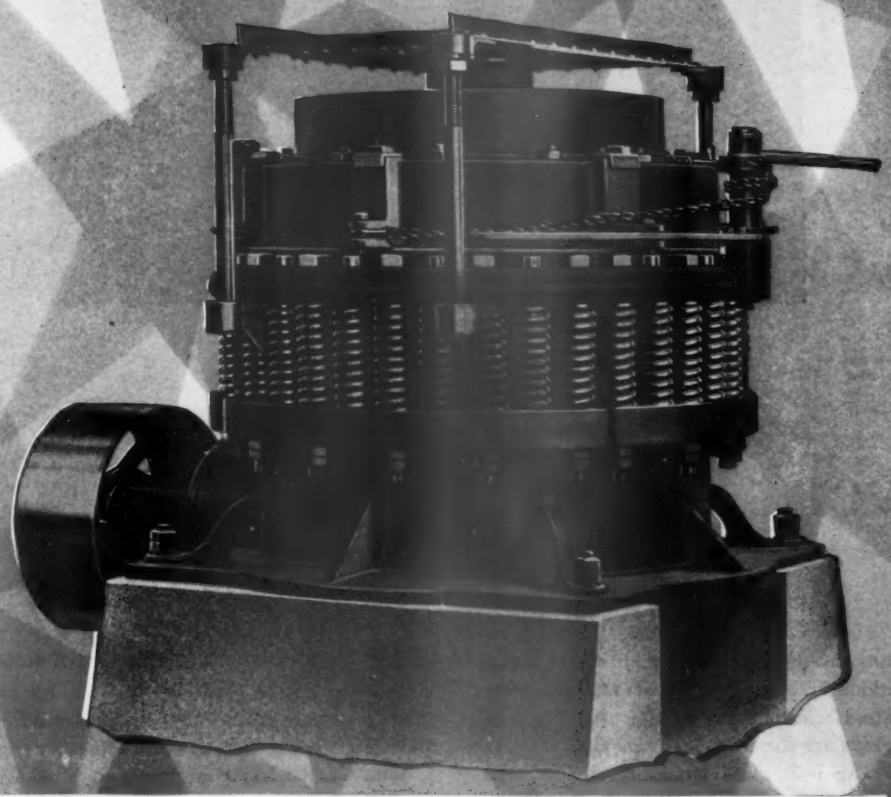

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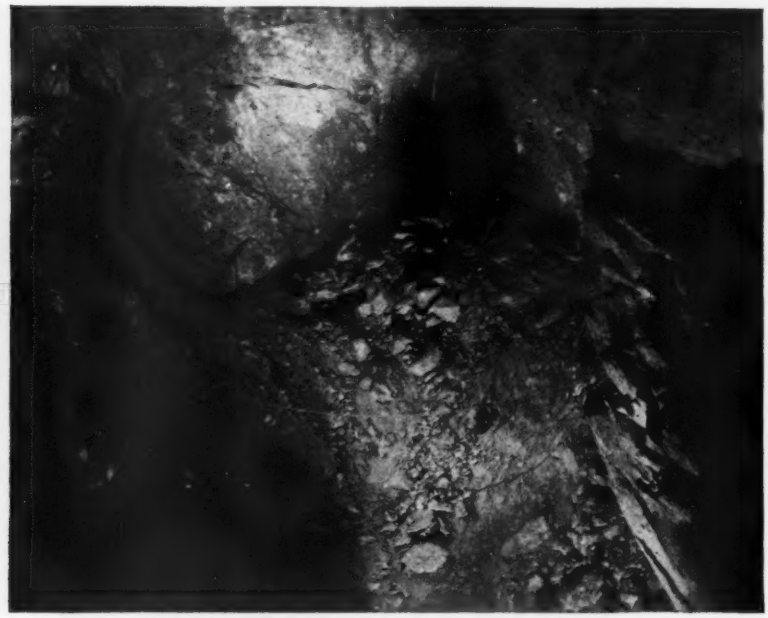
Cadet Light

Especially desirable for small stopes and roof trimming. Weighs 30 lbs. charged. One full charge burns for 5 hours.



This photograph was taken in a large zinc mine. The stope is about 50 ft. high. Notice how clearly the boulders on the slope can be seen. One Carbic Light (Style No. 2) was used for illumination.

Style No. 2

For illumination in large stopes. Weighs 37 lbs. empty and 115 lbs. charged. One full charge burns for 12 hours.

Prevent accidents in the stopes —*use more light*

THE constant danger that exists in stope mining operations is well known to safety engineers and operators. Roof falls and boulders rolling down the slope are the frequent cause of accidents. With only the individual lamps carried by the miners it is difficult for them to see the condition of the stope. More light will help prevent these accidents.

A powerful flood light

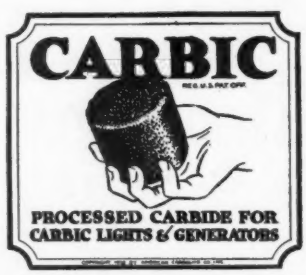
The Carbic Flood Light is exceptionally well suited for stope illumination. Tests carried on during the past year in metal mines in various sections of the country have proved the advantages of the Carbic Light for this purpose. A Carbic Light will clearly illuminate the largest stope so that the entire working area stands out in sharp relief.

The Carbic Light is not new

Its dependability has been proven by more than 14 years of use on the surface. Thousands of Carbic Lights are being used by contractors for night work.

The Carbic Light is simple in construction. It can be charged in three minutes. There are only three parts. It is portable. It can be easily carried from stope to stope. It is absolutely safe. If it is knocked over, the water runs out and generation stops immediately. The Underwriters' Laboratories, Inc., list the Carbic Light as standard.

If your jobber cannot supply you, write to our nearest district office.



Carbic is distributed by the Union Carbide Sales Company through its national chain of warehouses and is sold by jobbers everywhere.

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CARBIC LIGHT

Type M-3 Section Insulator Switch
Working voltage 750. Fully described on page 563 of O-B Catalog No. 20.

O-B

SECTION INSULATORS

—for lower ton-mile cost—

WHAT happens when you have a trolley break or a trolley line to be extended to new diggings? Must you disconnect the power back at the power house or entry—interrupting all haulage—to safely work on the trolley in but one section of your mine?

If you do, what happens in the other sections—are they producing? Certainly not! These sections are shut down for the want of power. And a shut-down of this nature greatly increases production costs, for men and equipment both are idle. Tonnage falls off, but the investment you are making in men, machinery and property rights continues. Thus is the cost per ton increased.

Because it is a simple matter to sectionalize your trolley lines, you can avoid these expensive shut-downs. O-B Section Insulator Switches have done the trick in many mines. With these O-B Switches you can isolate the section where repairs or extensions are being made—thus limiting your production stoppage to a small area.

Automatic Section Insulator
Used where it is desired to keep the trolley alive in any section only when a locomotive is operating in that section. Complete description on page 556 of O-B Catalog No. 20.

The cost is insignificant compared to the gain. The gain will quickly pay for your O-B Section Insulator Switches. Why not look into O-B Switches now with a view to avoiding such costly delays in the future? Pages 506 to 566 of O-B Catalog No. 20 give full listings on Section Insulator Switches. If you do not have a copy of this catalog, mail the handy coupon below.

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Canadian Ohio Brass Co., Limited
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886M

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Title.....
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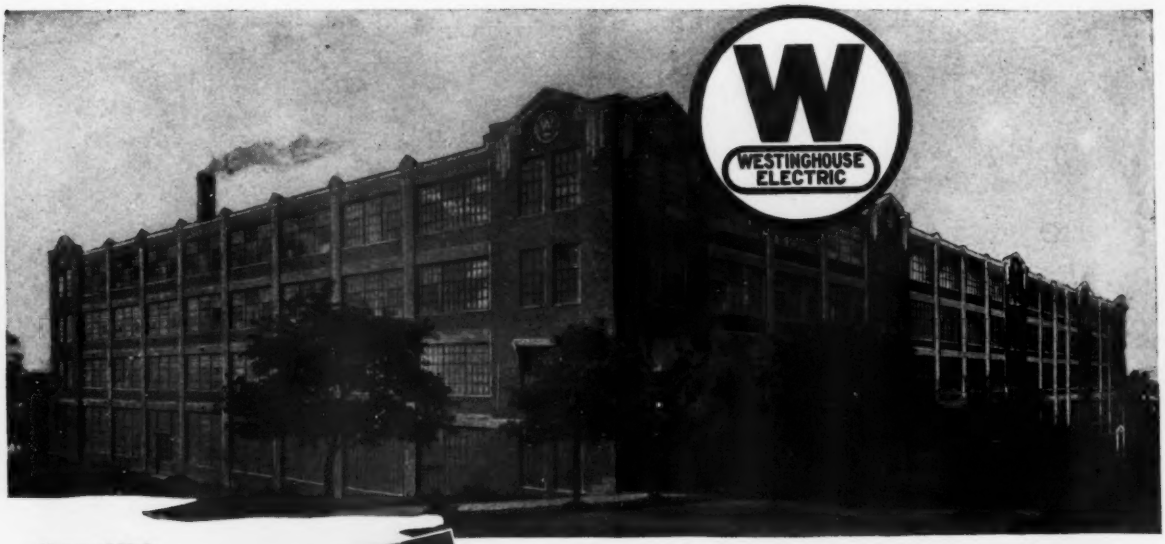

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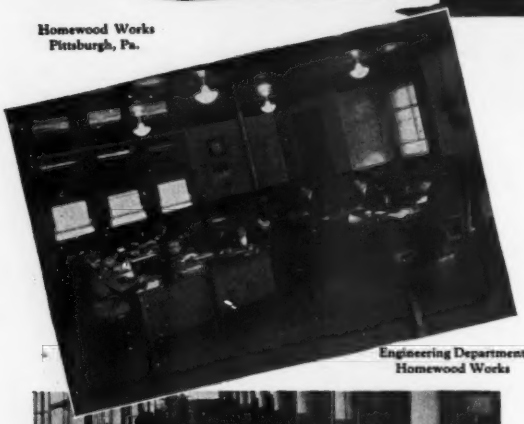
Pittsburgh, Pa.



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First Step

to

Lower Maintenance

RENEWAL parts made by the original manufacturer are designed to produce the best performance from the entire unit.

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Special attention is paid to the inspection of renewal parts to insure that every part is interchangeable with the old part.

With the Westinghouse policy of carrying ample stocks in all the twenty-seven district warehouses, renewal parts can be obtained as required.

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Sales Offices in All Principal Cities of
the United States and Foreign Countries

Westinghouse

X-98717

"Plant Operations Entirely Suspended"

THE plant was only eight years old, yet all of a sudden the heating system broke down. Investigation revealed that the long horizontal runs of pipe were rusted full of holes. Followed weeks of complete shutdown while the pipe was dug up, new pipes laid, and floors and walls repaired. The loss and expense ran into thousands. Wise builders know that a factory heating system is subject to severe corrosive attack. They know that Byers Pipe resists corrosion to a remarkable degree.

A few dollars spent originally to get Byers Genuine Wrought Iron Pipe, in the above case, would have resulted in a system which would have served for a lifetime without serious trouble. On an average, Byers adds less than 10% to the cost of a heating system, while adding 100% or more to its life. It has all the enduring virtues of the honest, old-fashioned wrought iron, demonstrated through centuries of service. That's the stuff Byers is made of. Specify "the pipe with the Spiral Stripe."

Literature on request

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Established 1864 Pittsburgh, Pa.

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GENUINE WROUGHT IRON

Listed as standard by the Underwriters' Laboratories, Inc.

A simple little generator* with a fine record of performance

YEARS of service have proved the value of the Carbic Acetylene Generator for welding and cutting. You'll find enthusiastic users in every branch of industry. Thousands of these truly portable generators are in operation all over the country.

The Carbic low pressure generator is a marvel of simplicity. There are no moving parts. You can charge it in three minutes. It's really portable. Two men can carry it easily. It has unusual safety features.

The cost of a Carbic Generator is small and it is extremely economical to operate.

Send for our new catalogue.

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Unit of Union Carbide and Carbon Corporation
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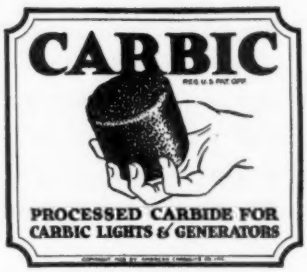

A standard drum of Carbic contains forty cakes, size No. 20. Carbic is distributed by the Union Carbide Sales Company through its national chain of warehouses.

CARBIC GENERATOR

For Oxy-Acetylene Welding and Cutting

**Anyone having a Carbic Generator is entitled to Oxweld Generator Service. Phone or write the nearest district office.*

MYERS-WHALEY SHOVELS

A Complete Line -- Machines for Every Service

THE "MYERS-WHALEY" SHOVELING MACHINE—THREE SIZES

There is a Myers-Whaley Shovel peculiarly suited to each particular phase and condition of underground mechanical loading. The well known Myers-Whaley Automatic Shovel is the machine for heavy work—grading—loading roof falls—brushing top or bottom rock—and under certain conditions for tonnage loading of coal.

The New Whaley Single Motion Shovel is peculiarly well suited for loading coal. Its advantages are: first, large capacity with no degradation or breakage of coal or raising of dust; second, thorough clean up of floor; third, wide reach; fourth, low height of shovel end.

THE WHALEY SINGLE MOTION SHOVEL—TWO SIZES

Let our engineers advise with you as to the selection of the machine best suited to your own conditions

WHEN WRITING FOR FURTHER INFORMATION, PLEASE GIVE US DATA ON YOUR MINING CONDITIONS

MYERS-WHALEY CO., INC.

Knoxville, Tennessee, U. S. A.

Easy---

Carnegie Copper Steel Mine Ties provide the easiest and quickest tracklaying possible. After the rail has been placed under the outside clip, simply hit the inside clip with any convenient tool and the rail is firmly secured, automatically true to gauge. That's all there is to it. The tie is complete in one piece, ready to lay. No spikes or bolts to get lost.

Carnegie Ties are light in weight. A workman can easily carry five or six and a section of track may be shifted as a whole. The use of a jumper or extension rail extends the track right up to the face of the coal.

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Wrought Steel Wheels for Mine Cars and Locomotives

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Our trained and experienced organization is available for preliminary discussions, mine examinations and final estimates of tonnage productions and costs with our units, under conditions determined by each property; while our demonstrating and service departments assure complete instruction of all operating crews, and close cooperation between the user and manufacturer for all required service.

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MANY coal operators believe from long experience and repeated trials that they cannot use high explosives satisfactorily because they are too strong and too expensive. But things that were true yesterday are not necessarily true today.

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Hercoal-F combines the good points of Blasting or Pellet Powder with the good points of a Permissible Explosive for blasting coal.

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COUNT:
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COMPARED WITH BLASTING OR PELLET POWDER:

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SAFER
—Hercoal-F is a permissible explosive.

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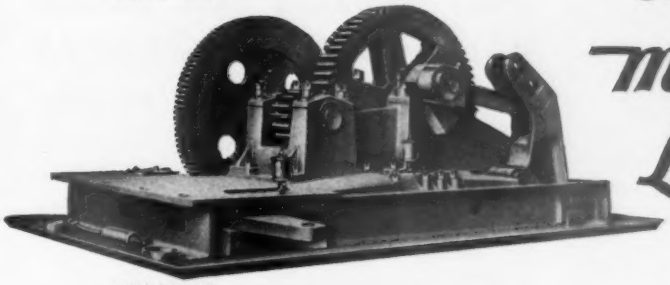

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CAN BE APPLIED UNDER ROOF CONDITIONS WHERE NO OTHER SYSTEM CAN BE USED

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many operators have decided that the use of HOAR SHOVELS provides a satisfactory solution of mucking problems.

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No Off-Set Trough Connections!

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Zinc Meta Arsenite—America's Own Wood Preservative has been adopted by The Western Union Telegraph Company for the treatment of poles. Being non-hygroscopic it is even better adapted for damp underground use which causes the flowing and shifting of other preservatives. Zinc Meta Arsenite completely penetrates evenly and thoroughly. The wood is permanently protected against the changing hot and cold, damp and dry conditions which are continuously encountered in mine work.

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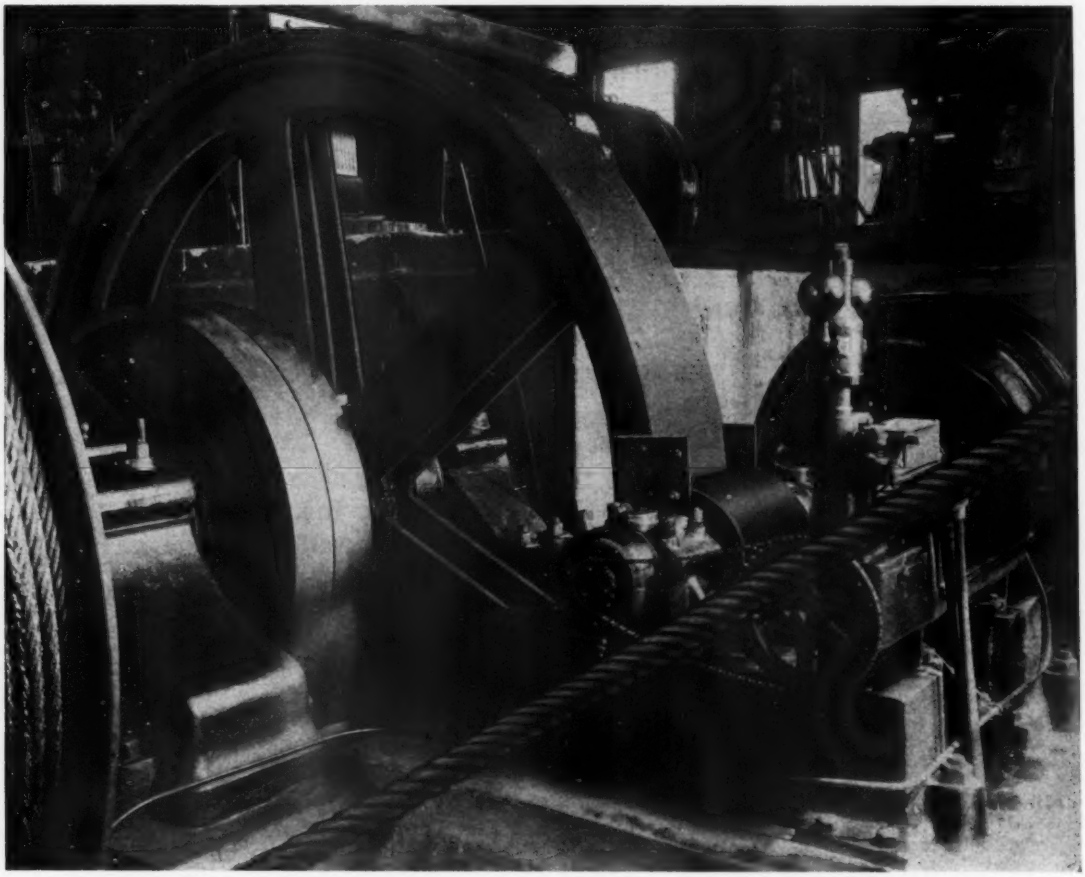
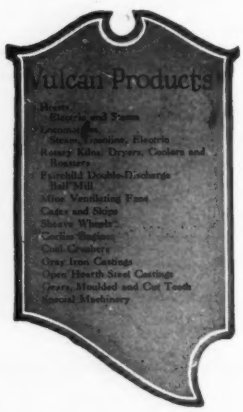
KEYSTONE WOOD PRESERVING COMPANY K WP C PHILADELPHIA, PA.

Saving expense in the CHANGE *from* STEAM *to* ELECTRICITY



A 300-H.P. geared electric hoist for changing over a 26" x 42" first-motion steam hoist to a single reduction electric hoist, complete with VULCAN safety devices and air brake equipment

by a minimum change of HOISTING EQUIPMENT



In changing hoisting equipment from steam to electric drive there is no necessity for doing away with much of the equipment—the drums, drum shafts, etc. Much expense can be saved with efficient results by using this same equipment together with the old engine bearings, connecting a new disc to the old crank disc, thus forming a rigid coupling connecting the new motor drive to the old drum shaft and drums. Changeovers of this kind are proving very satisfactory and we will be glad to consult with you about your problem.

The drive illustrated above is as completely protected by VULCAN safety devices as if it were a complete new electric hoist. Operating conditions for this hoist are as follows:

Hoisting in balance	
Capacity	200 Gross tons per hour.
Depth of shaft	315 feet.
Rope speed	700 feet per minute.

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As a user of Linde Oxygen you get a product of uniform high quality and prompt delivery service. *But are you making full use of Linde Process Service?*

Linde Process Service is always ready to help you with any welding or cutting problem. It will show you how to get the best results in the most economical way.

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The Standard Oil Company (Indiana) has developed a line of lubricants especially designed to meet the requirements of air compressors and pneumatic tools. Just which of these lubricants is best for your needs is a question that our lubricating engineers will be glad to assist you in answering.

A responsibility that modern mining methods is forcing upon you

MINING associations, mining publications and engineers are today giving great attention to mechanical mining. As mechanical means of mining increase and production becomes more dependent upon machinery alone, correct lubrication grows more essential.

The Uncle Henry Mine at Saginaw, Michigan, has long realized the necessity of correct lubrication and has found the answer in *Standard Oil Company (Indiana) Lubricants.* They say—

"Our complete mine lubrication is handled very satisfactorily by Standard Oil Company (Indiana) products."

Other mines have likewise testified to the high efficiency of these lubricants. They have found that when our proper oil or grease is selected and used on a unit of equipment the lubrication is as nearly perfect as lubrication can be.

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Mines Nos. 1 and 2—Berwind, W. Va.

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CAPACITY	—	600 Tons per Hour.
SCREENING	—	7 Sizes Made on Shaker and Vibrating Screens.
PREPARATION	—	Lump and Egg Coal, Hand Picked. All Sizes Under $2\frac{3}{4}$ in., Cleaned by Air.
LOADING	—	Six Tracks, Five Loading Booms.
DUST COLLECTION	—	Practically 100 Per Cent by Bag Filters.

Engineered, Manufactured, and Erected by Fairmont

Write us for Details

FAIRMONT MINING MACHINERY COMPANY
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FAIRMONT ENGINEERING PRACTICE IS BACKED BY A QUARTER CENTURY OF EXPERIENCE

The Alaska Juneau Gold Mining property is situated about two and one-half miles east of the city of Juneau

A THREE MILLION TON GOLD FILLING

JUST two and a half miles east of Juneau, Alaska, is a body of low-grade ore containing not over 90 cents worth of gold to the ton. None of the hardy souls that went to Alaska during the big gold rush would have bothered with it. But the Alaska Juneau Mine by adopting the most modern equipment and engineering methods sends to its mills daily between 12,000 and 13,000 tons of this low-grade gold ore cheaply enough to make a good profit.

The process consists chiefly of cutting out huge cavities about 7 feet high and 300 feet by 200 feet with the necessary draw-holes and then caving tons of rock into these cavities by blasting. The rock is drawn out at the bottom where secondary breaking is done in bulldozing chambers. These cavities or stopes are made into open pits as quickly as possible and the open walls blasted with powder drifts.

Recently a powder drift blast using 21,000 pounds of du Pont 40% Red Cross Extra filled one of these cavities and a large pit

DU PONT
REG. U. S. PAT. OFF.

with 3,000,000 tons of gold ore. The descriptions under Figures 1 and 2 explain the details of this giant gold filling.

The blast actually broke out 250,000 tons and loosened over 3,000,000 tons, using only .045 pounds of powder per ton of ore broken.

There's an important significance about the use of du Pont explosives and accessories wherever operations call for particular exactness and for rigid economy. Quality of manufacture and 125 years of explosives experience make a very real difference. Even in smaller, less exacting operation there is a decided economy in time, labor, safety, and actual money in using the best explosives and accessories obtainable.

Call in a du Pont representative for that next job. Use his experience and expert knowledge. It may save you a great deal, right now and for years to come.

E. I. DU PONT DE NEMOURS & CO., INC.

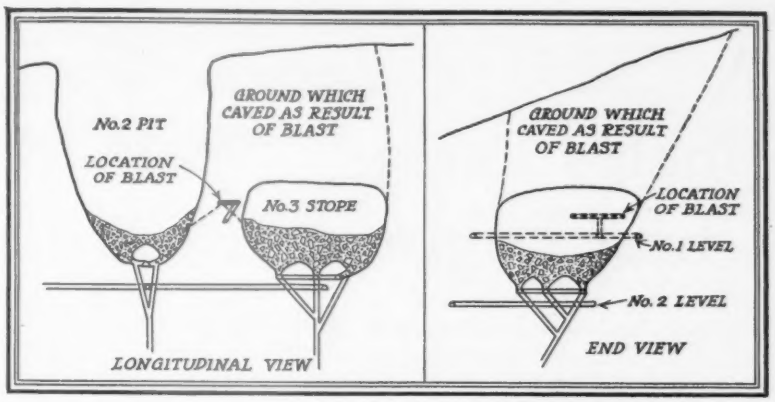
Explosives Department

WILMINGTON, DELAWARE

FIGURE 1—(*At the right*)

This large blast was located in the middle of a pillar 80 feet wide and 200 feet long which separated No. 2 open pit from No. 3 stope and gave support to it at one end. A fault, nearly vertical, made up a part of the other end of the stope, while a strike formed its footwall.

No amount of natural caving took place because of the strength and toughness of the metagabbro and slate in which the ore occurs.



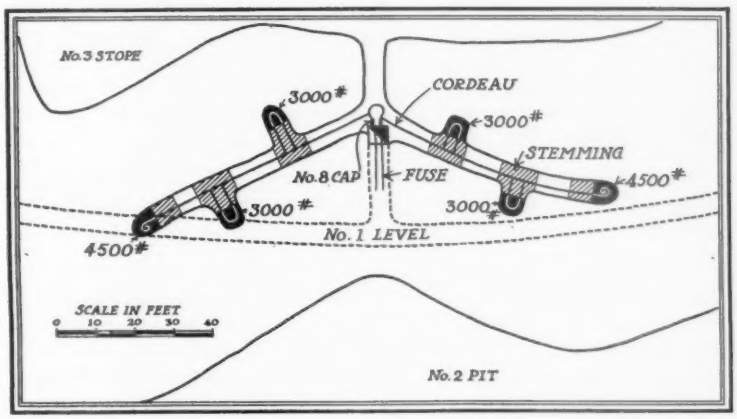


FIGURE 2—(*At the left*)

A powder drift was driven 65 feet each way from the top of raise 40 feet above No. 1 level, south. The powder drifts were driven about parallel with the axis of the pillar so that the burden averaged 40 feet. Six piles containing an average of 3500 pounds of du Pont 40% Red Cross Extra dynamite were packed tightly against the solid rock. One charge was placed in each face while the other occupied 10-foot spurs spaced equidistant along the drifts.

The charges were connected in duplicate by double-countered Cordeau fuse and then carefully tamped for about 15 feet with fine rock stemming. The Cordeau was detonated by du Pont No. 8 blasting caps and two 30-foot lengths of single-tape safety fuse.

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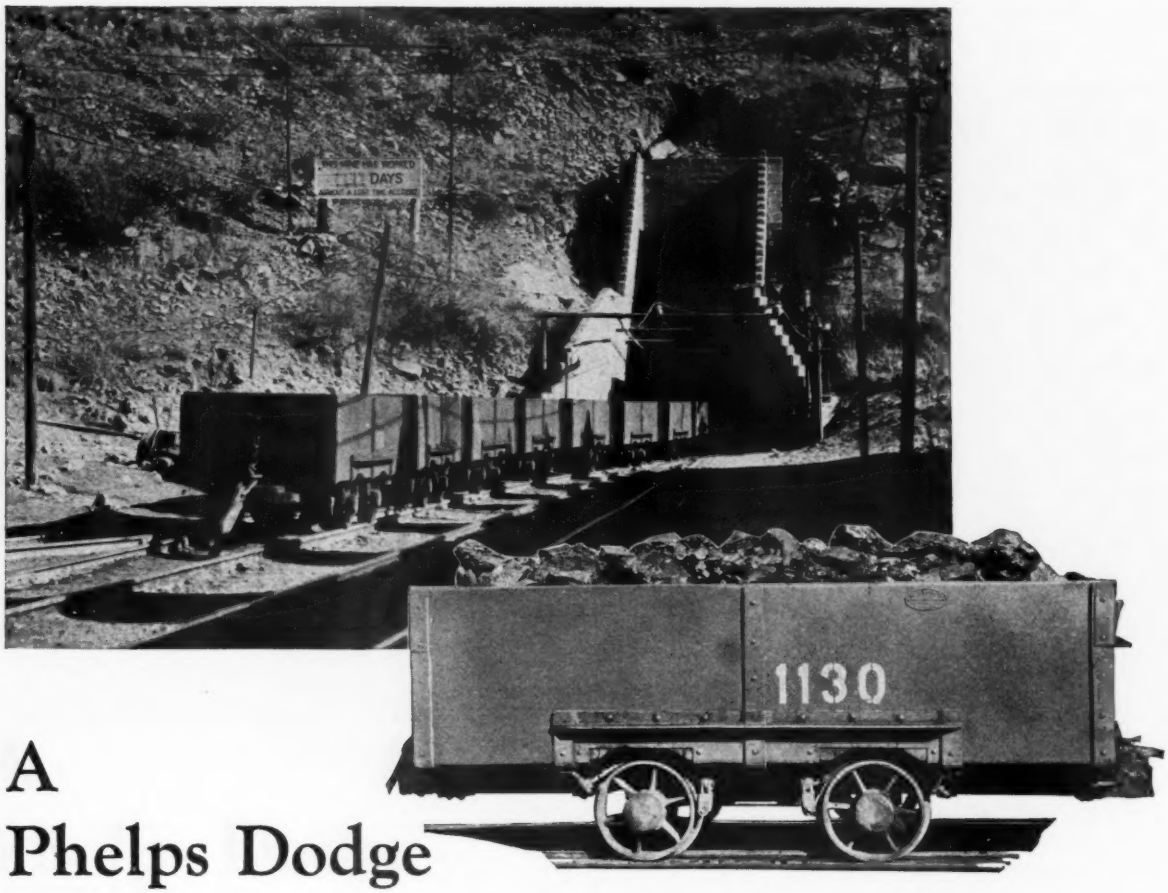
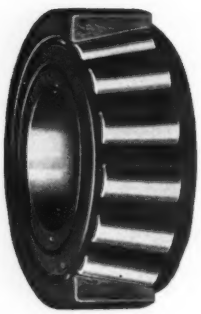


A Phelps Dodge Chief Engineer, *re* Timken Bearings



Said Mr. W. C. Holman, Chief Engineer, Phelps Dodge Stag Canon Branch, addressing the Rocky Mountain Coal Mining Institute:

"Timken Bearings have been adopted on all new cars. Our experimental cars equipped with Timken Bearings have been in service for two years and none have been out of the run for bearing trouble. No adjustments have been necessary up to this time. The cars are greased every four months, notwithstanding the fact that they could probably run a year without greasing. The number of miles a car travels in one year at our mines can be conservatively estimated at 3000 to 4000.

"The Timken Bearing does away with bearing wear on wheels and axles, reduces lubrication expense, keeps the wheels in perfect alignment and is easily maintained in proper adjustment.

"The mechanical advantages claimed for the design of the Timken Tapered Roller Bearing in regard to the ability to carry thrust loads simultaneously with radial loads, are no doubt familiar to all of you." All those mechanical advantages are made possible only by the exclusive combination of Timken tapered construction, Timken *POSITIVELY ALIGNED ROLLS*, and Timken electric steel!

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

TIMKEN *Tapered Roller* **BEARINGS**

The
MINING CONGRESS JOURNAL
A Monthly Magazine—The Spokesman For The Mining Industry—
Published By The American Mining Congress

VOLUME 14 JULY, 1928 NUMBER 7

Editorials

A Candidate For The Presidency

HERBERT HOOVER, the Republican candidate for the Presidency is primarily a mining man. The fame he has so justly attained rose from a mining foundation. As a thinker, builder, dreamer, he has attained a place in our national life that makes him a great asset to this country, no matter to what political party he pledges allegiance. The qualifications outlined by John L. McNab, who presented his name to the Republican Convention, are sufficient to permit the mining industry to point with extreme pride to its first Presidential aspirant. Summed up these are: "Efficient Engineer, Practical Scientist, Minister of Mercy to the Hungry, Administrator, Executive, Statesman, Beneficent American, Kindly Neighbor, Wholesome Human Being."

Conservation In Mining

IN NO other industry has the struggle for conservation and elimination of waste in production been advanced more rapidly than in mining; and this struggle has been financed and paid for by the mining industry itself, without material aid in any direction from the Government. Great progress has been made in the development of methods and devices for decreasing costs of extracting ore, and for the utilization of low grade deposits that only a decade ago had little or no commercial, and in some cases not even speculative, value. Mr. Hoover recently stated his views concerning this all-important phase of mining which will bear repetition:

"Some people conclude from the non-renewable character of the mineral supply that they must shortly be exhausted. The practical question is one of time, and time in these matters needs to be measured in generations, and apprehension of exhaustion needs be tempered with many probabilities including the advance in technical methods of extraction. In some of our minerals such as coal, iron and building materials, we can, through a knowledge of their geological structure and occurrence, make fairly good estimates of our reserves. We know that they will outlast many generations of Americans. In non-ferrous metals and oil, geology affords us no great basis for an estimate of future supply. We only know of the occurrence of minerals of this type by actual exposure of them and we can thus make no estimates except upon reserves which have been proved by actual development by the process of mining. To develop them ahead merely for national satisfaction of assured future supply would imply an unbearable waste of capital. The consequence is that in these groups there is never a demonstrable assurance of more than a few years' supply ahead of us. Yet we have never failed from year to year to find new deposits and extension of old deposits. We might add also that not every acre of this land has been fully explored as yet. Not a year goes by without new discovery. * * * The industry and the Government, has from time to time the responsibility to take stock of our mineral resources and to devise such measures of conservation as are practicable and possible. More particularly do practical measures lie within the realm of economical utilization and the elimination of waste in production."

Encourage Mine Development

THE mining industry, in all its branches, must be kept active, and in a healthy, prosperous condition. Prospecting for new reserves must be encouraged. Exploration and development work must be continuous. Research and investigation must be constantly carried on. Investment in mining enterprise must not be discouraged or diminished by a critical or indifferent attitude on the part of the Government. Government policies in the administration of mining laws, in the enactment of legislation affecting the mining industry, and in the taxation of mines, both generally and locally, must be liberal, friendly and cooperative; and in every way should afford all possible protection and safeguards against uneconomic and destructive tendencies that from time to time appear.

This is particularly true when it is understood, that "When the raw materials of our mines emerge from manufacture with the added expenditure of labor and capital upon them, they have a wholesale value of over fifteen billions of dollars. And in this, the second stage of their application, they give employment to another two million workers and support to about ten million more of our people. A large portion of these manufactured commodities must filter through the retail trade. Their total value when delivered to the consumer exceeds twenty billions of dollars. And from this distribution arises the support of many more millions of our people."

Mine development must be encouraged, because of its vast economic importance in our national life.

Mine Taxation Heavy

IT IS a well-known fact that mining is heavily burdened with taxation. In proportion to its aggregate net earnings, the industry pays a far greater tax for the support of Government than most other industries, not excepting even agriculture. The tax paid the Federal Government, although somewhat less in the aggregate by comparison with net profits, than that of most other industries, except agriculture, is not a small sum; but that paid to state and local govern-

ments of the mining states, by the same method of comparison, is greater than that of any other industry. It has been officially stated that the minerals industries in their raw materials stage alone pay direct taxes to the Government amounting to over five times all the other raw materials industries put together.

This is a fact that few people, not even Government officials, seem to realize. Politicians prefer to ignore the situation, because it does not, generally speaking, help to secure votes to sympathize with the mining industry or take a wholesome interest in its problems. If the majority of our people could be made to visualize the fact that a healthy, prosperous mining industry is a prerequisite to a healthy, well-balanced revenue from taxation, the industry's problems might be more easily solved.

Economic Status of Mineral Industries

SINCE the War, practically all branches of the mining industry have passed through periods of severe depression and economic pressure at one time or another. Certain branches have not yet found the solution to their difficulties. In the case of all branches the problem of reducing costs of production has been tremendous; but it has been met in part by cutting overhead expenses to the bone, by the development of new methods of mining the ore, and extracting the mineral, and through research and invention.

The stability of the mining industry is a large part in the stability of the whole country. A recent statement by a Government official points out that price levels for mining have been subnormal, and that if we examine the price levels of our important minerals we shall find that they are, compared with pre-war, below the average level of all commodities except perhaps in the case of anthracite coal and lead.

The miner, with the farmer, is suffering from the fact that the price levels of their commodities are below the relative average price levels of the commodities they must buy and the wages they must pay.

Statistics at the beginning of the year indicated that while the average prices of all commodities today are about 47 percent above pre-war, copper is 21 percent below pre-war; silver, 8 percent below; iron ore, 14 percent above; zinc, 12 percent above; aluminum, 7 percent above; crude oil, 18 percent above.

The Western Division

THE annual meeting of the Western Division of the American Mining Congress has been announced for the week of September 10. Taxation, tariff, marketing and gold mining will be among the major subjects scheduled for discussion. In this, as in previous meetings, other organizations representing groups engaged in the metal mining industries of the West are giving splendid cooperation and will participate in the convention. The American Institute of Mining Engineers, the Arizona Chapter of the American Mining Congress, and the California Mineral Development Association are working with the Western Division to bring about a most successful and fruitful gathering of mining men.

Rehabilitation of the gold-mining industry is a problem that will interest every western mining man. The gold-mining industry has not declined because the mines have exhausted the gold, nor because there is no market for the gold. On the contrary, there are large known reserves of gold-bearing ore, and the market for the gold will absorb all that can be produced. The trouble is that the cost of producing gold has gone up while the sale price has remained stationary as fixed by statute. The price is not affected by the law of supply and demand. And the Government supplies the jewelry and dental supply manufacturers with the gold at cost, thus preventing the gold-mining industry from ever reaching a stage where it could enjoy a sellers' market.

The problems of taxation are largely State and local; but a uniform policy will help in curbing public expenditures and leveling off the upward trend of the taxation burden. The tariff is, of course, a Federal question. There may be an attempt made to secure a general revision of the present tariff law, and it is just as well that the western metals industries be prepared to justify and defend the schedules that safeguard their very existence. Better marketing of lead and zinc, copper and silver no doubt will come in for thorough discussion. These are all problems in which two or three or four heads will be better than one in finding the solution.

The Safety Competition

THE results of the National Safety Competition as announced by the United States Bureau of Mines should do much to encourage the mining industry, and at the same time dispel the notion that is being broadcast in certain quarters that the mining industry is remiss in its safety work. W. W. Adams, statistician for the Bureau, even goes so far as to say that the accident records of the winning companies in the competition are "beacon lights in the world of accident prevention." The actual statistical result is indeed inspiring. The records set by the winning companies and those competing with them certainly may be pointed to with justifiable pride.

Month after month we have published articles, written by the men responsible for such results, which present safety plans and organizations that are paying real dividends to the companies sponsoring them. In the metal industry, in the coal industry, and in the quarrying and non-metallic industries the result of patient, painstaking education is showing results. Much credit should be given to those great organizations who have had the foresight and perseverance in forcing recognition of "Safety First" as a paramount issue in mineral production. The work of the Safety Engineer and his organization is rapidly approaching the recognition in industry they deserve, and the day is fast approaching when the mining industry will reach the safe and sane ground of universal appreciation of a safety program.

Filibustered To Sleep

A CONSIDERABLE number of important bills were filibustered to sleep just before the close of the last session of Congress; but they remain on the legislative calendar, some in the House and some in the Senate, and will be up when Congress convenes for the short session. The Boulder Dam bill is the unfinished business of the Senate. The line-up in favor of this measure may change somewhat after the election. Another important bill on the Senate calendar relates to restricting the right of courts to issue injunctions in labor disputes. The House calendar likewise lists several sidetracked measures that will be up for consideration next December. The legislative calendar is not heavily loaded. Congress made a better record than even its leaders expected in disposing of the deluge of proposals that kept the Government's printing presses going at the beginning of the session.

Meeting Customer Demand

EACH year the coal consumer is becoming more critical and customers who formerly bought on price alone are now insisting on quality as well as price. Coal is sold in a buyers' market and the buyer is demanding clean coal. Until recently it was generally held that the proper place to clean coal was at the working face underground and any impurities which the miner could not remove were not considered detrimental to the product, but this opinion is rapidly being discarded and those who are still holding to it are experiencing great difficulty in convincing the consumers that this view is correct.

Progress in coal cleaning and preparation is keeping pace with the customers' demand and as is usually the case, it is the farsighted coal operators and manufacturers who are leading in this progress. A few years ago, loading booms were new—today they are part of the regular equipment in every modern tipple. A few years ago, picking tables were regarded as an unnecessary refinement—today, coal operators are congratulating themselves if they happen to be mining a seam from which it is possible to remove the impurities by hand cleaning on picking tables. A few years ago, an operator who installed a mechanical cleaning process was considered to be working under a handicap—today, those who have such installations are considered to be fortunate in possessing a distinct advantage over their competitors who are not so equipped.

Mechanical cleaning, originally designed for the smaller sizes only, is being perfected each year to properly prepare increasingly larger sizes of coal, new installations are continually being made and mechanical cleaning is rapidly being developed to the point where hand methods will no longer be able to compete.

The Rock Dust Remedy

IN its current quarterly publication, the American Association for Labor Legislation announces that its standard bill for rock-dusting of coal mines will be pressed for adoption in the 17 bituminous States holding legislative sessions in 1929, and in which rock-dusting laws have not been enacted.

Rock dusting to prevent accidents is a comparatively new safety feature. It has demonstrated its worth in a sufficient number of instances to warrant the serious consideration of the industry. The report on this subject made to the Cincinnati convention indicates that its adoption is going steadily forward, and without any legislative coercion.

At the present time six States have rock-dust laws—Utah, Pennsylvania, Wyoming, West Virginia, Ohio and Indiana. The bill sponsored by the Association is based upon the Rock Dusting Code developed as a part of the safety code program of the American Engineering Standards Committee and cooperated in by all of the leading mining organizations. The code in itself is of course not compulsory, and is a purely voluntary recommendation.

Rock dust is not a cure-all. Its blanket adoption will act as a preventive, but unless it is taken at its true worth—simply a preventive measure—and every other safety precaution adopted with it, it is apt to be a disappointment to its advocates. Because a mine is treated with rock dust is no guarantee that explosions cannot occur. Just as much care should be exercised in a rock-dusted mine as in a mine without this precaution.

Rock dusting is being rapidly adopted in those districts where coal-dust explosions may be expected, and will not require legislation to force its adoption.

Mechanization vs. Man-Power

AMERICA has led the world in intensive mechanization of industry, and many ascribe our continued prosperity to this fact.

Samuel Vauclain, president of the Baldwin Locomotive Works, gave us something to think about in his recent address before the National Electric Light Association. He painted a picture of Business of the Future that is somewhat difficult to follow, but which in the light of past performance of industry is possible. Mr. Vauclain believes that the mechanical age is upon us with full force. He even goes so far as to state that the time is not far distant when the pick and shovel will be found only in the museum; when the vast majority of the work now manually performed will be mechanically performed. He pointed out that at their new Edgemoor plant they have installed 339 traveling cranes, eliminating the necessity for manual transference of materials and equipment.

Economy in man power and further efficiency in production must be the marching song of the age. More power to the great inventive genius of this country which has given to us, and will continue to give to us, a progress whose brilliancy has been unequalled in history.

Mechanization of industry is in its infancy. It is the ultimate solution to the problems facing many industries.

Importance of Standardization

EFFORTS toward standardization are regarded by many people as a hamper upon individual initiative and an attempt to make everything alike. Some of the opponents of standardization urge that the waste occasioned by myriad gauges is really beneficial.

The American Mining Congress has for a number of years been a member of the Amernean Engineering Standards Committee and has tried to clear the recommendations of its standardization committees through that body, but the growth o ifts work without sufficient financial support, has made it impossible for it to accomplish all it expected and delays in the consideration of proposed standards have lead to considerable friction. There have recently been some substantial changes made in the plans of its operation and Mr. William J. Serrill, Assistant Manager of the United Gas Improvement Company, of Philadelphia, has been elected to the chairmanship of the committee.

The importance of standardization, notwithstanding its opponents, is of very great value to all industries and particularly to the mining industry. The average manufacturing plant is located near some central source of supply for the securing of parts, while the mining plant is located where the mineral exists and usually at a point distant from where supplies can be obtained. The mining plant is therefore, required to keep on hand a considerable supply of the various parts and where each machine had its own size screw bolts and other parts, it was necessary to keep a number of stocks of supplies in order to have them available in times of breakdown.

But it has another advantage which perhaps has been lost sight of, viz, that the cost of production is less for a larger number of parts. For instance, the American Engineering Standards Committee in February, 1927, adopted standard hexagonal head cap screws which can be obtained at a cost of $9 per hundred, while the old style screws in the same size but of different makes and in small lots, cost from $49.90 to $70 per hundred.

The lsolated manufacturing plant to matter what its character has a decided interest in such standardization as will enable it to reduce the stock of supplies and

parts required, and all plants, wherever located, have a decided interest in securing these parts at that low cost which is made possible by bulk manufacture.

More active interest in standardization work and a better support to the American Engineering Standards Committee will unquestionably produce valuable results to industry.

Power Labels And Pays—Congress Franks

THE Federal Trade Commission has been engaged in an investigation of the Power Industry. Much has been made of the fact that this investigation has shown that the power companies have furnished information to schools and other educational sources, furthering the merits of private ownership. The fact that such information was plainly labeled as to source has been pretty generally buried by those attempting to discredit private industry.

Since when was it a crime to preach the doctrine of private enterprise? And why is it more of a crime to preach its virtues than that of Government ownership?

Scarcely a week passes that this publication does not receive an inquiry from some student—grade, high school, or college—with a request for debate material upon Government vs. Private Ownership of Industry, and invariably that inquiry is prefaced with the remark that there is available to them a great amount of information favoring Government ownership and nothing for the other side of the question. And, generally speaking, this pro-government-ownership material was distributed under the congressional franking privilege.

A perusal of the Congressional Record will reveal a vast amount of propaganda in favor of Government ownership of industry, and some Senators have no hesitancy in utilizing the Record as a free medium for the dissemination of their views on this subject.

Undeniably there is propaganda in behalf of private ownership, just as there is propaganda for Government ownership.

Percentage Depletion

A PLAN for allowance of depletion on a percentage basis was strongly urged in connection with the recent revision of the Revenue Act. The reason for this proposal was not so much because of any question as to the general soundness of the theory of depletion allowances in the present law as it was because of difficulties in administration. That depletion is a proper deduction in computing net income of mining companies seems so well recognized and fully established as a part of our law that we seem past the time when arguments are necessary to justify it. This applies both to depletion of cost, of March 1, 1913, and of discovery values. The difficulties seem to be in arriving at the right measure of allowable depletion.

The Revenue Bureau not unnaturally takes the same conservative position as to depletion allowances which it takes for all other deductions. The taxpayer is faced with the burden of proof, which is particularly difficult for smaller companies or for those with deposits not susceptible of accurate measurement. Many companies have, after rather lengthy and onerous procedure, reached results which they feel to be reasonably satisfactory. Where a satisfactory basis for computing depletion per unit of product has been used, it is probably true that no simpler method could be adopted for future allowances on ores thus valued.

That some, and even many, companies have thus obtained their satisfactory allowances which they can in the future apply in a simple and easy manner is, however, little consolation to the many companies who have in a maze of technical procedure found themselves with inadequate or even negligible allowances.

It seems useless now to discuss whether or not the Department might in the first case have more liberally construed certain provisions of the law so as to eliminate some of these difficulties. The Department has taken a position which, rightly or wrongly, it feels to be justified and to which it seems determined to adhere unless and until some change may be made in the law. It does not seem antagonistic to any such reasonable provision as Congress might be willing to make which would fairly deal with those taxpayers as find themselves in difficulties because of present provisions.

Studies By Congress And Department

THE most practical manner of relieving the situation seemed to be the introduction of a provision for allowance of depletion on a percentage basis. As a result of studies made by representatives of the Congressional Joint Committee on Internal Revenue Taxation and representatives of the Treasury Department, a provision for depletion allowances based on a percentage of gross income seemed the best solution. Their studies showed 15 percent of gross income to be a generally fair basis for metal mines. While this 15 percent was far below what many mines would be clearly entitled to and, in fact, was rather below the average of ores heretofore valued, it did not seem an unreasonable basis for what was, after all, primarily a relief provision to simplify procedure and avoid technical difficulties. The provision did not, however, go so far as to allow in all cases this 15 percent of gross, but it was to be coupled with a provision that such allowance should in no case exceed 50 percent of the net. Accordingly, such percentage depletion would have two limits: It could not exceed 15 percent of the gross nor could it exceed 50 percent of the net. This double limitation applied not merely as to different mines but also as to different years. Where and when profits were large, the limitation on gross would apply. Where and when profits were small, the limitation on net would apply.

In spite of these drastic limitations, the proposal seemed of sufficient merit that it was generally accepted by the mining companies as a satisfactory relief provision. Manifestly, however, it was not one which could be expected to supersede the present basis in the case of those who had succeeded satisfactorily in establishing their rights to a fixed unit depletion under the present more technical, but more exact, provisions, nor could it be applied in future cases where depletion on the basis of cost would exceed the percentage basis.

As the provision was introduced in Congress it related only to metal mines. There is naturally question as to whether some similar provision should not be made for the non-metals. Neither the Treasury Department nor the Joint Committee had completed their studies in this regard. Perhaps an even more serious difficulty was that in the latter part of the session the element of time became such an important factor that both in the Department and in Congress there was a reluctance even to consider a possible change in the depletion provisions. It is understood, however, that both the Treasury Department and the Joint Committee intend further to continue their consideration of this question so that it may be given adequate attention before the next revision of the Revenue Act.

SAFETY FIRST—MORE THAN A SLOGAN

By FRANK H. PROBERT*

THE hackneyed catch-phrase, "safety first," appealing as it was when first used, has become commonplace and may have lost its punch; it needs reiteration, emphasis and elucidation.

Safety first is more than a slogan; it is a prayer for protection from folly and carelessness; an invocation for men, women, and children to preserve what they possess and can never regain if lost; a petition to the heedless to see that their recklessness destroys no one's life, limb, or happiness. Man can not rebuild a human body or replace a soul. The conservation of human life is an industrial issue and all accidents are an injustice and an economic waste. The human unit has a value in the eyes of the world above property, above institutions. The wheels of industry stop when the life of the meanest workman is thought to be endangered. This holds true no matter what the urge for output, no matter what the damage to property, no matter what the loss or cost is to company, community or state in all occupations save that of a soldier. The cry, "Man overboard," will stop the leviathans of the deep, a fire-alarm disturbs business procedure, a mine accident is far reaching in its effect.

The United States has abundant mineral resources upon which an intense and competitive industry has been developed. We need men to keep up the pace in the international race for supremacy. Our wealth is not alone in our natural resources but in our people. Industry carries a costly expense account of inefficiency and absenteeism because of accidents. The mining industry directly touches over 2,000,000 workmen — including their families, 9 percent of the entire population of the United States. Indirectly all civilization is dependent upon mining.

The causes of mine accidents are the inherent risks of occupation, defective materials, rapidity of working, deficient illumination, inadequate ventilation, unfamiliarity with working places and methods used, carelessness and recklessness, ignorance and indolence, disobedience to orders, physical condition of workmen, faults of management, faults of co-laborers. Half the accidents occurring in and around mines are preventable. The "safety first" movement is the outcome of studied investigation, but in the pursuit of this reform there may be danger of going too far. The idealist will urge refinement of methods such as will inspire too great confidence in the workmen and perhaps make them careless in their false security. The manager, on the other hand, may be so desirous of increasing profit that he, even though recognizing the necessity of protection, postpones action because of initial cost. A balance must be established between these two extremes. Any system of safeguarding employes that minimizes the sense of personal responsibility tends to increase casualties. The onus rests on both employer and employe.

Safety work is not merely mechanical nor legislative, it is largely educational. With careless workmen all the devices and all the laws of the lexicographers will not prevent accidents. Men must be trained to think and act properly at all times. Possibly the nature of mining work and the environment in which it is done invites thoughtlessness or encourages the taking of a chance—a short cut. This may be due to ignorance, to recklessness, to lack of forethought, but it should never be mistaken for bravery. A man is worse than a coward who, in order to save himself slight effort, will endanger the lives of others. The principles of saving time are often applied unintelligently and may end disastrously for the offender, his associates, the industry and society. Better lose a moment than a finger; the day has 1,440 minutes, the hand but five fingers. Carelessness is a disease, and many of us are afflicted without knowing it. Education and personal discipline alone will cure it. Not infrequently the innocent suffer for the guilty. The child of a careless man is almost an orphan. Every man in or around a mine should discipline himself into a right mental attitude toward "safety first." He should be willing to obey orders, capable of understanding orders, and do the proper thing at the right time and regardless of whether he is being watched. No one has such a charmed life that he is immune to accident or injury. Agility counts for little if alertness is lacking. We need safe men as well as safe mines, although it can not be gainsaid that well-kept working places pay bigger dividends than well-kept hospitals and cemeteries. The safety device and the human element are the important factors in safety. Efforts toward advancement in mining are futile unless we have safe and sane methods to build upon. We need men to think safely, not merely to voice it.

A man well trained in safety may be classed as an efficient employe no matter what work he does. By training is meant something definite and specific, not alone the distribution of "safety first" literature or the indiscriminate posting of signs and slogans. Men working underground nowadays are assigned particular tasks; the miner seldom mucks and trams his own dirt; the timberman does not run the drill. Each man in addition to knowing the mine should know the hazards of his job. Studying accidents may be too late; best study the hazard. It is better to take pains in preventing accidents than to suffer pains as a result of them.

Conservation Of Human Life Is An Industrial Issue And All Accidents Are An Injustice And An Economic Waste—Safety Work Not Mechanical Nor Legislative But Largely Educational

Unfamiliarity with the mine and inexperience with the ground is a prolific cause of accidents. A recent study of employment and accident records of two large mining companies showed that injuries occurring during the first two months of employment numbered 48 percent; for the first two weeks 20 percent. The proper hiring (*Continued on page* 488)

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There Are Eleven Experiment Stations Located In As Many Fields And Employing 374 People — Pittsburgh Station Largest — Working Appropriations Very Small, But Investigations Cover Wide Fields

Pittsburgh Experiment Station, U. S. Bureau of Mines

The WORK *of the* EXPERIMENT STATION DIVISION, U. S. BUREAU *of* MINES*

By A. C. FIELDNER†

MOST of the investigative and research work of the Bureau of Mines is conducted at the mining experiment stations. These are located in suitable proximity to the mining regions or the mineral industries which they serve. There are 11 of these stations, but they are not all of the same size. The oldest and largest station is the Central Station at Pittsburgh, which has 267 employes; next in size is the Petroleum Station at Bartlesville, Okla., with 46 employes; the remaining 9 stations total 61 employes, or an average of seven per station.

A. C. Fieldner

The Pittsburgh and Bartlesville stations are in Government-owned buildings on Government property. The other stations are on State-owned property and usually occupy quarters at State universities, where they work in cooperation with the State mining experiment station or the mining and metallurgical departments of the university. Seven of the nine small stations were established under the Foster Act, passed in 1915, which authorized the establishment of 10 mining experiment stations and 7 mine safety stations, and also authorized the acceptance of lands, buildings and other contributions from the several States willing to cooperate under the act. Federal appropriation for each station established under this act is $25,000.

THE PITTSBURGH EXPERIMENT STATION

The work of the Pittsburgh Experiment Station, which includes the Experimental Coal Mine and Explosives Experiment Stations at Bruceton, Pa., consists mainly of research, investigation, and testing pertaining to the mining and utilization of coal, ferrous metallurgy, and safety in mines. The supervising engineer, who directs the operations of the mine safety stations and cars in various parts of the United States is stationed at Pittsburgh, and the research laboratories for studies of conditions pertaining to the health of miners, the effect of toxic gases, respiratory protective devices, gas indicators, etc., are located at this station.

The administration of the station is in charge of a superintendent who is an experienced research director and is, himself, in immediate charge of one of the research sections. The following list of sections into which the station is subdivided gives a picture of the varied lines of work carried on:

Ferrous Metallurgy.
Experimental Mine.
Coal Mining Research.
Electricity in Mines.
Explosives.
Fuels.
Coal and Coal Products Research—
  (a) Analytical Laboratory.
  (b) Microscopical Laboratory.
  (c) Coal Carbonization Laboratory.
  (d) Organic Chemistry Laboratory.
  (e) Physical Chemistry Laboratory.
Physics—
  (a) Cryogenic Laboratory.
  (b) Physical Laboratory.
Safety and Health—
  (a) Gas Analysis.
  (b) Gas Masks and Respirators.
  (c) Physiological and Pathological Research.
  (d) Pollution of Streams.

It is seen from this outline that many branches of engineering and science are represented — mining, mechanical, electrical and chemical engineering, physics, chemistry, microscopy, metallurgy, physiology, pathology, geology, and the subdivision of many of these sciences. Mutual consultation between members of the staff is an enormous advantage in working out engineering and scientific problems.

An outstanding example of such group research is the work done by the Bureau on the ventilation of the recently completed Holland Tunnels between New York City and New Jersey. This problem required the joint efforts of many specialists in technology. The mechanical engineer and the chemist determined the amount and composition of the exhaust gases given off by motor vehicles under various operating conditions. The physiologist and the chemist determined the effect of these exhaust gases on human beings and the maximum amount of these gases permissible in the tunnel atmosphere; and the ventilation engineers determined the power required and the method for dis- (*Continued on page* 488)

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HAZARDS *in* CONNECTION *with* CONCENTRATED MINING*

By D. HARRINGTON†

Concentrated Mechanical Methods in Infancy—Twenty Hazards Occasioned By The Newer System Outlined — Recommendations As To Safe Operation Made—Adoption Of Mechanized Mining Inevitable And Safety Rules Should Be Adopted As Rapidly As Possible.

THE introduction of concentrated systems of mining is largely dependent upon the assumption of much of the burden of underground work by mechanical contrivances, with consequent concentration of work and of the working force in general, but little attention has been paid the element of safety. Discussions of mechanical drilling, cutting, loading, conveying, hauling, etc., have ordinarily been characterized by an assumption (which is inferred rather than uttered) that safety will be enhanced rather than in any manner retarded or lessened by concentrated mining methods and devices. There have been a few attempts to show that mechanical mining is safer than are the more primitive ways of doing underground work by man power; a few figures or brief statistical records have been advanced tending to indicate that the concentrated systems using mechanical devices have actually shown fewer accidents per 100,000 tons of coal produced than has been the case in the same mines or mining regions when the older hand methods were utilized.

While there are plenty of good and sufficient reasons why the newer or concentrated systems using mechanical rather than man power can, will, and should be used in our mines, there is absolutely no justification for attempting to utilize these newer ideas without the taking of common-sense precautions looking to the safety of the mine and of the miners as well as to lower costs and to increased tonnage.

Generally it is futile to discuss dangers unless there can be given some specific cases of occurrence of accidents; unfortunately, notwithstanding the newness of this type of work, there is no dearth of such instances in connection with mechanical mining or with so-called concentrated systems.

One of the most alarming features about the newer systems of mining is the laxity in connection with ventilation.

Carelessness in the use of electricity in connection with scrapers, conveyors, loaders, fans, etc., is the rule rather than the exception. These electrical accidents are by no means infrequent; they are likely to become increasingly numerous, and their elimination is one of the real problems in connection with the newer mining systems.

The following are some of the hazards noted where the newer systems are used:

(1) In a conveyor or electric loader system operation one usually finds open arcing types of electric motors, switches, etc., at or very close to faces which give off, or are at any time likely to give off, methane; wires poorly insulated or bare are poorly placed and poorly supported.

(2) Much dust is thrown into the air in connection with conveyor or loader work, the very fine (hence most dangerous) dust settling on adjacent surfaces, especially in the open region from which the coal has been removed.

(3) Frequently blasting is done during the working shift, and it is not at all uncommon to see 50 or more pounds of explosive with 25 or more detonators on the floor within a few feet of electric wires or motors or the open lights of workers.

(4) When shots are fired during the working shift, the workers are withdrawn only a short distance, hence in case of a blown-out shot or gas ignition from blasting the workers are likely, in fact are almost certain, to be killed or at least seriously injured.

(5) In the hurry to complete the cycle of operations (upon returning after a blast) a minimum of attention is given inspection of the face region for methane or examination of roof conditions, and timbering is done before resumption of work only when absolutely necessary.

(6) Under some roof conditions an appreciable length of time elapses after blasting before the roof will actually fall in pillar or long-face work, and where there is an "urge" to complete the cycle of operations little or no time is spared to await action of the roof.

(7) Generally reliance is placed upon props (frequently with very few props in position) to hold the roof (even with an extensive worked-out area) or to determine the line of break in the roof; in most cases props are entirely inadequate for this service, and in the long run are more expensive than would be an adequate system of cribs.

(8) Scrapers, mechanical loaders and, to a smaller extent, conveyors tear out props or cribs.

(9) There is generally very little clearance or adequate guarding of moving or electrically-charged parts around mechanical equipment near face regions, and workers have a minimum opportunity to travel without being injured.

(10) Mechanical equipment, such as electric drills, blowers, mining machines, loaders, conveyors, and scrapers, is noisy, hence while in operation at or near face regions the noise from the equipment prevents the workers from hearing the more or less slight warning sounds generally given before a roof or rib falls.

(11) The advocates of nearly every so-called concentrated system give reason after reason why it is essential that single entries of various lengths are necessary, and each advocate advances reason after reason why single entries of 200 to 1,000 or more feet are safe, notwithstanding that it has been one of the axioms of safe and sane coal mining that under no circumstances should any single underground opening be driven to a length of more than 200 ft.

(12) One of the worst makeshifts to which resort is had in this single-entry driving is the use (or rather the flagrant misuse) of blower fans and tubing for ventilation.

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(13) Under stress of completing the cycle of operations in the concentrated systems there frequently is no hesitancy to allow (in some instances practically to force) workers to work around or under missed shots or to work in close proximity to missed shots while these are being removed or otherwise handled.

(14) When rock or extra large pieces of coal are brought down by blasting or happen to fall in such manner as to impede the operation of conveyors, loaders, scrapers, etc., there is little or no hesitancy in many mines to use the quick, lazy, and decidedly dangerous "adobe" or "sand-blast" shot rather than take the necessary time to remove the impediment safely by drilling a hole and using inert stemming with electric blasting with the shift out of the mine.

(15) Economically the weak point in most of the concentrated mining systems centers in haulage, and here again safety is sacrificed. Trolley locomotives and trolley-locomotive wires are brought almost up to dusty or gassy faces, and open-type cable-reel locomotives or open-type storage-battery locomotives are sent to similar places.

(16) One of the safety advantages claimed by adherents of the newer concentrated systems is that of more intensive supervision; yet in many instances the work is placed in charge of some young electrician, mechanic, or engineer who knows little, and cares less, about haulage, timbering, blasting, ventilation, etc., though he is intensely interested in the electrical or mechanical details of the equipment.

(17) Most of the conveyor, scraper, or loader systems demand that the coal be in fairly finely divided form and that it be thrown well out from the face; to accomplish this, comparatively large charges of explosive are used, in some instances the charges of permissible explosives exceeding the permissible limit of 1½ pounds per hole. These excessive charges are dangerous in that they are more likely to precipitate blown-out shots or cause explosions than would charges within the permissible limit of 1½ pounds per hole; in addition, the excessively large charges have a decidedly harmful effect upon the roof and tend to increase accidents from falls of roof.

(18) The newer systems with long faces require the drilling of numerous holes (10, 20, or more in some cases) for blasting, this being many more than in the ordinary room or entry face, with its 2 to 5 holes. Where the holes are hand drilled, the workers are prone to drill as few as possible, since hand drilling of blasting holes is decidedly laborious; this automatically results in forcing the heavy loading of the comparatively few holes drilled.

(19) One of the most essential features in safe operation of concentrated systems and one most difficult of attainment is to have ample illumination; under no circumstances should open lights be allowed, and ordinary types of incandescent lighting are dangerous for use at or near faces likely to be gassy or dusty. The safest lighting available is that of storage-battery lamps of the permissible type.

(20) One feature of the concentrated intensive mechanized systems of coal mining that should occasion alarm is the fact that these systems generally cause practically continuous operation of electrical equipment at or very close to faces that are gassy or dusty, and this continuous use of electrical equipment at the face throughout the shift is decidedly more dangerous than the more or less intermittent use of mining machines or electric locomotives under older systems; even the latter equipment is dangerous in the older systems unless adequately safeguarded.

Recommendations as to Safe Operation in Concentrated or Mechanical Systems of Mining

(1) Where concentrated systems of mining are used, there should be ample, competent supervision; as a minimum there should be at least one supervising official or "boss" in constant attendance for about each 25 underground workers. These immediate, "always on the job" bosses should be experienced in mining as well as have a good working knowledge of electricity, machinery, and handling men.

(2) It should be known to a certainty that those in actual charge of underground operation of the concentrated systems are in full sympathy with the system, at least in so far as giving it a fair, square trial is concerned.

(3) Ventilation should be even more carefully planned and conducted to and past working faces than where older systems of work are used. In a coal mine, under no circumstances, should single entries be driven longer than 200 ft., and under no circumstances should reliance be placed on any form of intermittent ventilation, such as is almost invariably found where blowers and tubing are used.

(4) None but the safest available types of electrical equipment, wiring, and installation should be allowed when mechanical work is being done at or close to face regions; this is true even where no explosive gas has been found.

a. Wiring should be thoroughly insulated, well supported, and strung along the rib or other place, as far as feasible from probable contact with workers.

b. Bare or poorly insulated wires or open electrical switches should not be placed along or even fairly close to the roof in parts of a mine where methane may accumulate if ventilation is interrupted.

c. Only permissible electrical equipment should be used at or near faces that are, or are likely, to be gassy or dusty. Open types of electrical equipment, such as conveyor or hoist motors, trolley or cable-reel locomotives, drills, etc., are decidedly dangerous when used near working faces from which coal dust is given off and are much more dangerous when explosive gas also may be present.

d. Incandescent electric lights and light wires are dangerous when used at or near faces that are, or are likely to be, dusty or gassy. Only up-to-date permissible storage-battery lighting should be used.

e. Although open-type electric motors or switches or bare electric wires should not be allowed at or near faces that are or may become dusty or gassy, it is realized that such equipment is being, and probably will continue to be so used, and it is suggested that such equipment is much more likely to be partly safe if kept fairly close to the floor rather than close to the roof, the latter being the usual practice.

(5) There should be ample, safe clearance for workers around mechanical equipment used at or near faces, the clearance being such that workers are not required to pass over or under moving or electrically charged equipment with the possibility or probability of being injured when so doing. Moving belts, gears, etc., on equipment used at or near face regions should be safely protected by adequate guards.

(6) The noise made by machinery makes it difficult, if not impossible, to hear the usual warning sound given by overhanging roof or rib material before it falls. Every feasible means should be taken to reduce noise where mechanical equipment is used at or around face regions; in connection with certain types of mechanical equipment, such as conveyors, the use of water not only tends to reduce noise but also aids materially in reduction of dust in and around the equipment and in the general surrounding atmosphere.

(7) In general, it is much safer and even less expensive to protect concentrations of workers in the newer systems by use of cribs (which may or may not be removable) rather than to depend upon props. Props should be used as an auxiliary to the cribs or as to supplement the cribs.

(8) When timber at or around mechanized faces is torn out by machinery or by blasting, then there should be no delay in its replacement, even when such

action may cause temporary interruption of the usual coal-producing work.

(9) After blasting there should be no hesitancy in taking sufficient time to place timber before allowing the loaders to start operations. Many accidents occur through overeagerness to start loading as soon as possible after blasting, practically irrespective of roof conditions.

(10) Where at all feasible no blasting should be done when the working shift is in the mine, and all blasting in coal mines should be done by competent shot firers using only permissible explosives shot electrically, with not over 1½ pounds of explosive per hole, and with holes well tamped with incombustible matter (in other words, coal-dust should not be used for stemming). By far the safest method of coal-mine blasting is that where all explosive is held out of the mine during the working shift and all holes are loaded by shot firers after the shift and are fired electrically from the surface with all persons, including the shot firers, out of the mine.

(11) While the above methods of blasting are absolutely practicable, in addition to being safe, it is recognized that many concentrated mechanized systems are dependent upon being able to blast at any time; hence the following recommendations are given as to blasting practice when the working shift is in the mine, with the intent to safeguard as much as possible a practice known to be inherently unsafe:

a. All holes should be loaded and fired by shot firers.

b. Only permissible explosive should be used in a coal mine, whether to bring down coal or to shoot rock. Certainly no black blasting powder or dynamite should be used in any coal mine while any men are in the mine. No hole should be charged with more than 1½ pounds of permissible explosive, whether the men are in or out of the mine, and a sufficient number of holes should be provided to allow using less than 1½ pounds of explosive per hole.

c. Blasting should be done by permissible single-shot electric blasting units.

d. All holes should be tamped with inert stemming.

e. There should be no solid shooting of coal or "adobe" blasting of coal or rock.

f. Holes should not be loaded and tamped while workers other than the shot firers are closer than 25 ft.

g. Under no circumstances should holes be loaded while electrical equipment, such as electric drills or electric coal-cutting machines, is working within 25 ft.

h. Preferably the face region should be well wet down before blasting.

"There is every reason for belief that mechanized concentrated methods of mining present numerous advantages and that they will spread fairly rapidly through the coal-producing industry of the United States. There is no question that these methods are now in many instances being used unsafely and unwisely, and there is also no good reason why they can not be made safe. On the contrary, most of them can and should be made safe, and the sooner the unsafe methods and practices are discarded the fewer disasters there will be."

i. Workers should be withdrawn at least 500 ft. before blasting, and ample warning given haulage and other adjacent workers; and loaders and other face workers should not be allowed to return after the blast until the face which has been blasted has been given a careful examination by a competent fire boss for explosive gas as well as for roof conditions or possible missed shots. It is important that ample time be given the above inspection to make it a thorough one; otherwise there are certain to be numerous disasters in the concentrated working of coal mines. Likewise ample time should be taken to remove any dangerous condition before workers are permitted to resume loading and like operations.

j. Where shots fail to detonate, loaders and similar workers should not be allowed within 50 ft. of them until these shots have been fired or the charge has been removed from the hole.

k. It is recommended that if the CO_2 method of blasting now in use in a few Indiana and Illinois mines proves safe and efficient this method, or one similar to it, be substituted for the usual types of explosives where it is considered necessary to blast while the working shift is in the mine.

(12) With the concentration of workers and of tonnage effected by the newer systems there should be ample opportunity for better rather than the poorer ventilation usually found at the places of concentrated work, as compared with the greater scattering of workers and working places under the older systems.

a. As heretofore stated, single entries longer than 200 ft. should not be allowed under any circumstances. They are difficult to ventilate, and in case of a fall men are likely to be trapped.

b. Blower fans and tubing should not be allowed in any coal mine; however, it is recognized that they are being used, and probably will continue to be used, and the following requirements should be kept rigidly in effect if this equipment is to be kept in even reasonable safety.

1. They should be kept in operation 24 hours per day.

2. The region surrounding a fan should be securely fireproofed, particularly if the fan is electrically driven.

3. Electric wiring around the fan should be well insulated and well supported.

4. Electric switches at or around the fan should be of enclosed type.

5. Preferably the fan should be operated by compressed air.

6. The fan should be located in strictly intake air and under no circumstances nearer than 300 ft. to a face likely to give off methane.

7. The tubing should be fireproof, or at least fire resistant, and it should be adequately supported from the roof and under no circumstances lie along the floor.

c. Workers should be withdrawn from any place or face where electrically driven machines are in use when the methane content is over 1½ percent.

d. When a fall cuts air circulation from any working face using concentrated mining no workers should be allowed in the region (other than a limited number to restore air circulation) until ordinary ventilation has been restored. This seems an unnecessary recommendation, yet cases occur where the desire to complete the cycle of operations leads to the forcing of work even when conditions are known to be dangerous.

(13) No non-permissible electric locomotives should be allowed close to any face which gives off, or is likely to give off, methane; this includes cable-reel and non-permissible storage-battery locomotives.

(14) Under no circumstances should trolley locomotives be used in return air or within 300 ft. of any face that gives off, or is likely to give off, methane, or within 100 ft. of any place where explosives are being used to charge drill holes.

Conclusions

There is every reason for belief that mechanized concentrated methods of mining present numerous advantages and that they will spread fairly rapidly through the coal-producing industry of the United States. There is no question that these methods are now, in many instances, being used unsafely and unwisely, and there is also no good reason why they can not be made safe. On the contrary, most of them can, and should, be made safe, and the sooner the unsafe methods and practices are discarded the fewer disasters there will be.

EXPERIMENT STATION DIVISION, U. S. BUREAU OF MINES

(*Continued from page* 484)

charging the gases from the tunnel. An actual model tunnel was constructed underground at the Bureau's Experimental Mine to test various methods of ventilation and prove the data obtained in the earlier investigations. The States of New York and New Jersey came to the Bureau of Mines for the solution of their ventilation problem because no other institution in the country had the combined facilities and personnel necessary to carry on this research.

The Pittsburgh Station is equipped with its own power plant, machine and woodworking shops, glass-blowing and instrument shops, drafting and photographic departments, library, and, in fact, all the accessories and services necessary to a modern research institute.

Each year the Carnegie Institute of Technology assigns graduate students in mining and metallurgy to work on problems in the station laboratories under the direction of a member of the Bureau's staff. This fellowship research is conducted with the advice and cooperation of advisory boards representing the industries of the Pittsburgh district.

The Experimental Mine and Explosives Experiment Station at Bruceton, 13 miles from Pittsburgh, are important adjuncts to the Station proper. Experimental work on the study and prevention of mine explosions is conducted in an actual mine in the Pittsburgh coal bed. On the surface of this 40-acre tract are the various galleries and other equipment for testing the permissibility of explosives for use in coal mining.

Petroleum Station

The Petroleum Experiment Station at Bartlesville, Okla., bears the same relation to the petroleum industry that Pittsburgh does to coal. It is located in a petroleum center, and has the advantage of close contact with the industry that it serves. The State of Oklahoma cooperates with the Bureau in contributing $50,000 annually toward support of the work of the station.

The Other Experiment Stations

The other nine experiment stations of the Bureau are occupied principally with metal mining, ore dressing, metallurgical and nonmetallic mineral research. Their locations and work engaged in are as follows:

Name of Station	Location	Work Engaged In
Non-Metallic	New Brunswick, N. J.	Non-metallic minerals and potash.
Southern	Tuscaloosa, Ala.	Beneficiation of low-grade bauxite and phosphate rock.
Mississippi Valley	Rolla, Mo.	Milling and ore dressing of lead-zinc ores, and beneficiation of fluorspar.
North Central	Minneapolis, Minn.	Iron ores and blast furnace metallurgy.
Intermountain	Salt Lake City, Utah.	Flotation and metallurgy of complex lead, zinc, copper ores.
Southwest	Tucson, Ariz.	Metallurgy and mining of low-grade copper ores.
Rare and Precious Metals	Reno, Nev.	Rare and precious metals.
Northwest	Seattle, Wash.	Coal washing and non-metallic minerals of the northwest.
Pacific	Berkeley, Calif.	Physical chemistry of non-ferrous metallurgy.

Since the working appropriations to these small stations are limited to $20,000 each, no major investigations can be undertaken at any of them except with material aid from the State or the mining industry. When such aid is not available, then the work is necessarily along small-scale laboratory lines of such nature that do not require expensive equipment or supplies. The average personnel of these stations consists of seven employes:

1 supervising engineer.
1 associate engineer, chemist or metallurgist.
1 assistant engineer, chemist or metallurgist.
1 or 2 junior engineers, chemists or metallurgists.
1 laborer or mechanic.
1 clerk-stenographer.

The relative smallness of the Foster experiment station as a research unit may be seen by comparing their technical staff in point of numbers with the technical staffs of each section of the Pittsburgh Experiment Station. There are 9 technical sections at Pittsburgh, with an average of 15 technical men in each section. The small Foster station averages only 5 technical men to the entire station. Obviously, the mining industry must keep this in mind when comparing the output of work and the achievements of the various experiment stations of the Bureau of Mines.

SAFETY FIRST—MORE THAN A SLOGAN

(*Continued from page* 483)

and firing of men are phases of the safety problem; a high labor turnover is conducive to high accident rate.

To what extent *laissez faire*, lack of interest and understanding, indolence and ignorance are contributory factors to industrial accidents is difficult to determine. Casualties have not decreased in proportion to the emphasis placed upon prevention, perhaps because to many employes work has become drudgery. Play is pleasurable activity engaged in for its own sake; work is directed to other ends than the activity itself—it may become monotonous and wearisome. Drudgery is activity in which the end alone is desirable—the pay check. Transforming work into play depends upon the attitude of mind towards work. Is there not some way by which the interest of the workman may be aroused to an appreciation of those things which bring lasting satisfaction, to the joy of the accomplished task, the knowledge of work well done? Mechanization of industry, important as it is in promoting productivity and lowering costs, has tended to make of men machines, automatons. Man labors to maintain his physical comfort in many cases. Safety may be promoted by making excursions into the byways of understanding, by adventuring into the realms of human motifs. When mental processes are not exercised because of habituation, the mood of reverie prevails, and absent-mindedness begets all manner of trouble.

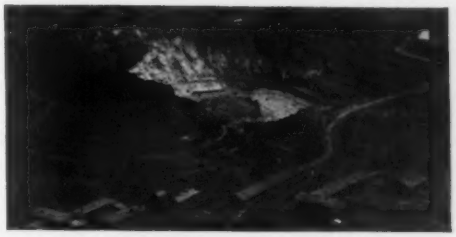
The whole problem is exceedingly delicate, the phrases "safety first" and "stop, look, listen" have been grossly overworked; they startle rather than teach, by constant repetition they may defeat their purpose. They may do violence to the innate spirit of adventure deep seated in all men. Education is the process by which one becomes fitted to experience the satisfactions of life in the fullest and deepest sense. The spirit of caution should enter into man's activities, not born of fear or apprehension, nor prompted by slogan, but an alert, operative caution engendered by knowledge and understanding. He is free from harm, who even when safe is on his guard. The spirit of safety is more potent than the safety device.

Good health and a sound body are man's greatest assets; they are, however, constantly threatened or menaced. The hazards of mining are not confined to shaft or stope; they are also of the trail and camp. Thought should be given to healthful and comfortable living conditions. A sick man is a menace to his coworkers. Disease is often the forerunner of disaster. From whatever aspect we approach the question, we arrive at one conclusion—prevention is better than cure. To this high purpose we should dedicate ourselves; it offers abundant reward in contentment, happiness, relief from suffering, better morale, output and profit.

METALS

GUY N. BJORGE
Editor

Practical Operating Problems of the Metal Mining Industry



SOLVING VENTILATION PROBLEMS *by* MECHANICAL MEANS

By CHAS. A. MITKE*

Mechanical Ventilation Preserves Health, Increases Efficiency, And Safeguards Miners In Event Of Mine Fires—Practical Solution Of Underground Air Conditions Is Through Introduction Of Large Volumes Of Surface Air, Properly Coursed Through Workings

THE purpose of mechanical ventilation underground is to preserve health, increase working efficiency, and act as a safeguard to the miners in the event of mine fires.

Deficient ventilation lowers a man's vitality and increases his susceptibility to disease, particularly diseases of the lungs.

A gaseous, hot, humid atmosphere quickly induces fatigue, which decreases the miner's power of production, or efficiency, as it is most generally called. This, in turn, has its effect on the mining cost.

Many mine disasters might be avoided entirely, and the casualties and property loss in others greatly minimized, if the proper ventilating systems were installed and in operation, so that air currents might be under control and the fire area isolated by means of ventilating doors.

U. S. Bureau of Mines.
Wahlen differential pressure gauge measuring differential pressure of section of adjoining airways

HEALTH

Cool, comfortable conditions, without air movement, so frequently attained in mechanically ventilated buildings on surface, are rarely possible underground, particularly in deep mines. The surface air invariably has to travel long distances down the shaft and through drifts before it reaches the stopes where men are working. Consequently, it picks up many impurities in this distance and suffers a considerable increase in temperature, due to absorption of heat from the rock walls before it ever reaches the workings where its main duties begin.

Quite frequently traveling ways and workings are damp, and even if they are not excessively wet water trickling down an intake air shaft will add considerable moisture to the air, and has been known to raise the moisture content as much as 50 percent to 70 percent. The exhaust air from the men themselves produces some carbon dioxide and moisture; decaying timbers also produce carbon dioxide; powder smoke, occasioned by blasting, adds more carbon dioxide, and large clouds of minutely pulverized rock; while the exhaust from drilling machines contributes foggy, compressed air and small particles of oil. Each day's work adds to the impurities already in the mine air, and thus an unhealthy condition is created, which soon impairs the health of the workers, unless the mine atmosphere is purified of its gaseous and deleterious contents by the introduction of large volumes of fresh air from surface.

EFFICIENCY

To prevent fatigue and maintain maximum efficiency the air must appear "fresh" and have a cooling effect upon the body, in order that the latter may dispose of its heat without strain. It is the rate of cooling of the human system which is the controlling factor in determining comfort or discomfort. The cooling power of the air is influenced by three important factors—temperature, humidity, and motion of the air. If the temperature of the air is very low—which it rarely is underground—conditions are fairly comfortable as, under such circumstances, the men do not perspire excessively. Likewise, if the moisture content of the air is low, much greater heat can be experienced without discomfort than where the content of the air approaches saturation. However, if both the temperature and humidity are high, then relief can only be attained by putting the stagnant air in motion. The reason hot moving air is far more endurable than the same air when not in motion is due to the fact that air in motion has a greater evaporative power on the body than stagnant air. The

* Consulting Engineer, Phoenix, Ariz.

greater the velocity of the air, the greater its evaporative powers, and rapid evaporation is what makes for comfort and apparent coolness. This does not necessarily mean that the same volume of underground air circulated and recirculated through the workings will produce as good an effect as fresh air continually brought in from surface. Air in a mine soon becomes more or less saturated with moisture and laden with impurities. The higher the degree of saturation, the less its evaporative powers. To recirculate such air is therefore only to subject the men to unhealthy conditions, and the only remedy is to dissipate these impurities and substitute healthful for unhealthful conditions by introducing large volumes of fresh, clean air continually from surface.

It is difficult to set a standard that will meet all conditions. An atmosphere and air velocity suitable in a mine where blasting is practiced only at the end of the shift, would be inadequate in another property where continuous blasting must be carried on during the working hours. To eliminate continuous blasting in such cases would be to destroy the efficiency of the stoping system. Therefore the ventilation must be arranged to suit existing conditions, and the air currents must be sufficient to make this atmosphere a healthy place for the men to work in. Just for this very purpose alone some large tonnage producers circulate as much as 800 cu. ft. of air per man per minute.

A Safeguard Against Mine Fires

Mechanical ventilation has played an active part in the fighting of many mine fires. By providing control of air currents, it safeguards the men who are at work when the fire breaks out and who must seek surface through long drifts, raises, and shafts where, unless such control is possible, they are at the mercy of the fire gases. It is also of use in building up pressures to hold back smoke and gas and thus allow fighters to approach the fire area and either seal it off, or put out the flames, without endangering their health or their lives.

Take, for example, the case of a stope fire in a mine ventilated only by natural means, where the air currents change daily, depending on surface temperatures. Under such conditions the smoke from the fire is carried here and there throughout the mine as surface conditions change. Such uncontrolled air currents may, without warning, render main outlets impassable, and the men endeavoring to reach surface by such exits would, as a consequence, be trapped and suffocated.

On the other hand, if a mechanical ventilating system is in operation, the men feel assured that the currents will not reverse on them, and that once they seek the safety exits they are sure of getting out. Moreover, the installation of a mechanical ventilating system generally involves the installation of a number of doors underground for the proper coursing of air currents. At times of fire, these doors serve a double purpose, as they not only control the air currents, but may isolate certain sections, thus confining the burning area to a very small portion of the mine and preventing smoke and gas from spreading through the workings generally. Not only is this an advantage to the men escaping from the mine but enables the fire fighters to approach close to the fire and in many cases extinguish it in the early stages.

Along with mechanical ventilation, certain fire preventative measures should be considered when working out the problem. As stated above, mechanical ventilation involves the passage of large volumes of air at much higher speeds than natural air currents. The accepted practice is to make the main hoisting and man shaft a downcast, and set aside, as an upcast shaft, one that is not required as a traveling way for the miners. Under such circumstances, the main intake shaft should be fireproofed, so that there is no possibility of smoke or gas from a fire in this shaft entering the workings with the intake air currents. The speed of air passing through intake shafts in a mechanically ventilated mine may be anywhere from 1,000 to 1,500 ft. a minute. It may, therefore, readily be seen how essential it is to have the main downcast shaft fireproofed. Should the main drifts from the fireproofed intake shaft to the stopes contain much timber, provision should also be made for the control of air currents through these important passageways. Fire doors should be installed at certain points, and constructed in such a manner that they can be closed either by hand or automatically. Such control should be possible, not only from the drifts but also from the main stoping section, so that the moment an odor of smoke becomes apparent a man can press a button and automatically close the doors, thus preventing air from feeding the fire or the currents from carrying the gas into the stoping area.

Room for Further Improvement in Mechanical Ventilating Systems

While much has already been done toward better ventilation in the past 20 years—the writer having personally worked out and supervised the installation of ventilating systems in 18 metal mines—a great deal still remains to be accomplished, not only from the point of view of health and efficiency but also from the standpoint of fire protection. There are many mines where excellent ventilation prevails underground, and, on the other hand, there are cases such as a property visited last year, where the operator remarked that he couldn't use mules in a certain section of his mine because the air was so bad they could not do any work. Yet it never occurred to him that the miners working in these same stopes, and from whom a good day's work was expected, might be equally as sensitive to the effects of bad air as the mules.

The only practical solution of underground air conditions at present is by the introduction of large volumes of surface air, properly coursed through the workings. Many mines have efficient fan equipment on surface, but the coursing of the air underground is neglected.

The remedying of underground atmospheric conditions by the use of large volumes of air has not by any means reached its limits. There are a great many mines at present where underground conditions could be improved by the introduction of still larger volumes of air and its proper distribution through the workings. At some mines large fans are installed on surface or underground and, while large volumes are passing through the shafts, very little importance is placed on its proper distribution through the stopes. As a consequence, there is a great loss through short-circuiting, and much of the air passes directly through main haulage drifts and exits without penetrating the working places and affording relief to the men as was originally intended. Many times the writer has passed through well-ventilated drifts and entered adjoining stopes only to find the men working in a hot, humid atmosphere, while only a short distance away a current of fresh air was passing directly to the upcast shafts. Unless the distribution of the air currents underground receives the same careful attention as the fan installations on surface, the efficiency of the system is impaired, the men receive no benefit, and the company is not obtaining full value for its investment.

While other methods of relieving underground conditions have been tried out with varying success, they have not as yet been universally adopted, owing to the prohibitive cost and other disadvantages, and the one generally satisfactory remedy at present in use is the introduction of large volumes of fresh surface air. These may not always reduce the temperature, as some other methods attempt to do, but by putting the air in motion a cooling effect results and a temperature which with stagnant air was unbearable becomes comfortable when this same air is set in motion. The velocity of the air has a drying effect upon the mine, (*Continued on page* 495)

MECHANICAL VENTILATION *at the* MINAS *de* MATAHAMBRE

By GEORGE L. RICHERT *

This Mine, The Only Copper Producer In Cuba, Is Operated By One Vertical Shaft, And Is Producing From 12 Levels At The Rate Of 30,000 Tons Of Copper Ore Per Month—While Natural Ventilation Removed Gas And Smoke After Blasting, The Heat Was Oppressive, Temperature And Humidity Conditions Averaging About 80 —Description Of Ventilating System That Has Eliminated Many Difficulties

THE MINAS DE MATAHAMBRE, at present the only producer of copper in Cuba, is situated on the North Coast of the island, approximately 150 miles west of Havana. The mine has been worked by various operators for the past 15 years. In 1921 the property was affiliated with the American Metal Company, Ltd., and since that time has been operated by them.

The mine, operated by means of one vertical shaft, is producing from 12 levels at the rate of 30,000 tons of copper ore per month. The shaft, which is timbered, has three compartments; a manway and two hoisting compartments. Total cross-section area of the shaft is 60 sq. ft. The ore is hoisted in 3½-ton skips hung below double-decked cages, which are not changed during hoisting operations. Ore is taken from the 600 level, the first level below the collar of the shaft, and all intervening levels to the 1,700 level, which is the next to the bottom level. With three exceptions, the levels are 100 ft. apart.

Shaft of the Minas de Matahambre, Cuba

There are two 8-hour shifts six days a week. With the exception of the staff and some bosses, all labor is hired at the mine. There are approximately 500 men employed underground, and, roughly, 60 percent of these are Spaniards and other European nationalities. The Cubans are essentially farmers, and do not take to underground work.

The ore, which is chalcopyrite, lies in large irregular pipes with lenticular cross section, and is fairly regular in dip and strike. The ore is mined by the flat back cut and fill system, and with the exception of the flooring laid down after the first cut is taken, and the cribbing used in the manways and ore passes to the level below, no timber is used in the stopes until they have been worked to within 15 or 20 feet of the level above when filled square sets are used. However, former operators of the mine used square sets for all stoping, and the decaying of this stope timber may account in part for the excessive heat found in certain parts of the upper levels. On all levels the stations and approximately 20 percent of the drifts and crosscuts are timbered. This drift and crosscut timber does not decay unusually fast if it is in a wet place with a good circulation of air. However, timber in a moist place where the air is dead is short lived, as it is attacked by an apparent dry rot working from the inside out.

Before the installation of the fans the mine had a fairly efficient natural ventilation system. Aside from raises to glory holes, where fill for the stopes was mined, two lines of raises had been run from the 1,300 level to the surface and one line from the 700 level to the surface. Two of these lines of raises, the Nos. 42 and 46 lines, are single compartment, 5 x 6 ft., and the other, the No. 45 line, is double compartment, 5 x 10 ft. The single-compartment raises were used as manways and for ventilation. The double-compartment raise carried the "sand fill" pipe lines and was also used for ventilation. With the exception of development waste (which is disposed of by using as fill in stopes), practically all stopes are filled after each cut with deslimed mill tailings. Aside from these raise connections to the surface, the Matahambre Mine is connected on the extreme north end of the 900 level to a small mine called the Ruiseñor. The connection between the two mines is a double-compartment raise which is naturally down-cast. The natural ventilation made the main shaft down-cast, while the three raise-lines to the surface were up-cast. This has not been changed by the addition of the fans. While the natural ventilation removed the gas and smoke after blasting, the heat in practically all parts of the mine was oppressive. In certain parts of the 600 level it was impossible to work more than 15 or 20 minutes until it would be necessary to go to the shaft for a breath of cool air and a drink. This was not due only to the actual heat, but also to the lack of circulation of air in parts of the level where there was little or no work going on. On the lower levels the heat was less noticeable, due to better circulation of air and to a drop of a few degrees in temperature.

* Chief Engineer, Minas de Matahambre, Matahambre, Province de Pinar del Rio, Cuba.

In April, 1927, Mr. Charles A. Mitke, Consulting Engineer, of Bisbee, Ariz., made a thorough study of the mine ventilation and found temperature and humidity conditions to be as follows:

> Temperatures underground range from 71° to 93°, with the majority over 80°.
>
> There is almost complete saturation of the air in the mine, due to water in the shaft and drifts.
>
> With surface humidity of 46 percent air entering, the 1,200 level was 96 percent saturated.

Mr. Mitke suggested the increasing of the quantity and speed, or velocity, of the air entering the mine by the installation of three exhaust fans on the surface, the fans to have the following specifications:

> 3 mine fans, single width, single inlet, up-blast discharge, full housing, right hand, to be located on the surface, at the top of mine shafts, and operated as suction fans, drawing exhausted air from the mine. Fans and motors to be connected with chain drive; current, 60 cycle, 220 volts. Fans to have capacity of 45,000 cu. ft. and to operate against a minimum of 3½-in. suction (3½-in. water gauge).
>
> 3 50-hp. motors.

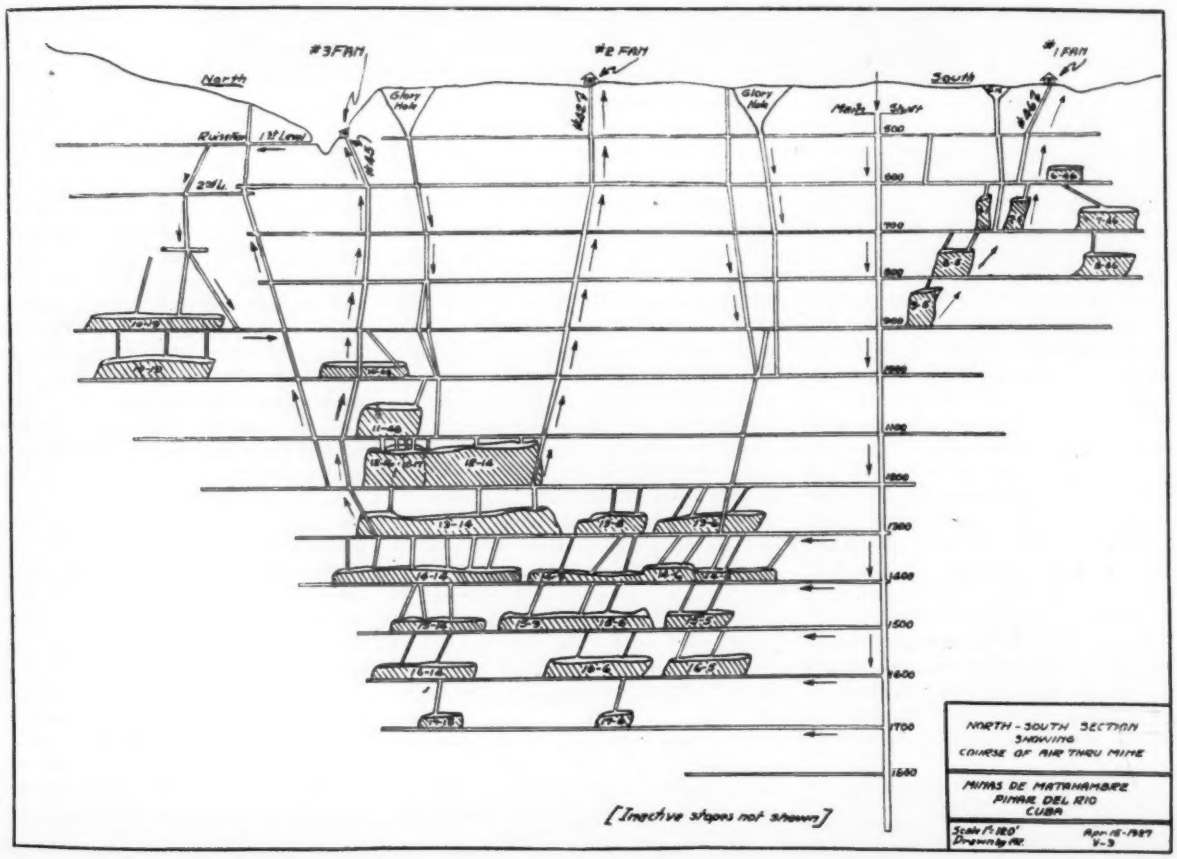
In addition to the fans, the necessary bulkheads, doors, and runarounds to properly direct the air through the mine. As there was approximately 21,000 cu. ft. of air per minute entering the mine by natural ventilation, this amount would be increased about six times. It was estimated that the mine shaft as an intake would take care of 72,000 cu. ft. per minute, the Ruiseñor connection 36,000 cu. ft. per minute, and other raises with surface connections would supply the remaining 27,000 cu. ft., while the three fans with a capacity of 45,000 cu. ft. each would exhaust 135,000 cu. ft. per minute.

As 74 percent of the mine production was coming from the 1,200 to 1,700 levels, 8 percent from the 700 level and 7 percent from the 900 level, it was decided to place the fans as follows:

> One fan over the No. 46 raises at the extreme south end of the mine.
>
> The second fan over the No. 42 ventilation raises, which extend from the surface to the 1,200 level.
>
> The third fan over the No. 45 ventilation raises at the north end of the mine.
>
> The No. 45 line of raises extends from the surface to the 1,300 level.

The fan over the south end of the mine, to be known as No. 1 fan, was to care for the south parts of 700, 800 and 900 levels. This necessitated the placing of one board and concrete bulkhead and one door on the 600 level to guide the air to the raise from the 700 level. The fan which was placed over the No. 42 ventilation raises, to be known as No. 2 fan, was to care for the central part of the mine from the 1,100 level to the 1,600 level. This necessitated the placing of 4 bulkheads and 11 doors. Two bulkheads were used on the 800 level, where a runaround from the main drift was provided to prevent loss of time in tramming by stopping to open and close doors. The fan over the No. 45 line of raises, to be known as No. 3 fan, was to care for the ventilation of the north part of the mine below the 1,200 level. This necessitated the placing of nine doors.

While waiting for the delivery of the fans all three lines of raises were cleaned and inspected, making sure there was at least 30 sq. ft. of cross section at all places. Iron ladders, replacing old wooden ladders, were placed in the No. 42 line of raises, so that it could be used as an emergency manway. The No. 45 line of raises had previously been equipped with ladders. As the Nos. 42 and 46 lines of raises were untimbered, they were timbered for 50 ft. below the surface and the No. 45 raise received an 8-in. coat of concrete on one compart-



Photographs showing location of fan houses

ment from the surface down 60 ft. In addition, two corrugated-iron buildings were constructed to house Nos. 1 and 2 fans. All doors and bulkheads as previously outlined were put in place and runaround on the 800 level driven. The wooden platforms in the manway of the main shaft were taken out to allow the full area of the shaft to be utilized. The platforms were to be replaced by steel grating, which would serve as a platform and offer as little resistance to the passage of air as possible.

The fan houses for the Nos. 1 and 2 fans were constructed of corrugated iron and are 24 x 16 ft. This gives ample room for housing the fans, the motor, and the starting equipment. To care for the No. 3 fan, which pulls from the No. 45 line of raises, an extension was added to the building housing the sand fill classifier.

As the Nos. 42 and 46 lines of raises connected with the surface well up on the side of Matahambre hill, it was necessary to transport all material for the installation of the fans as well as the fans and motors by means of oxen and a stone boat.

A separate power line was constructed from the central substation to the No. 3 fan and another to No. 2 fan. This provides for control of these fans either from the substation or at the fan. To provide power for No. 1 fan at the south end of the mine, a power line was run from the hoist house to the fan. With this arrangement No. 1 fan can be controlled from the substation as well as from the hoist house and at the fan.

The ventilation doors were made of double 1-in. boards with roofing paper in between. The door is hung, by means of heavy strap-iron hinges which extend across the door, on a frame set in concrete. The door is made to close against the frame, rather than set into it, to avoid sticking should the door swell. Canvas is tacked around the edges to avoid leaking when the door is closed. The door closes with the current, and on the upper levels it is difficult to open, due to the suction of the air.

With everything in readiness the fans were installed as planned. After testing the fans, measuring the pressure, etc., the fans were put into operation December 7, 1927.

The first noticeable change due to the operation of the fans was in the quantity of clothes worn by the men underground. Previous to the installation of the fans a pair of trousers cut off halfway between the body and the knee, canvas shoes, and a more or less abbreviated shirt, which as a rule was left at the station, was the uniform of the day. Within a few days after the fans started, the amount of clothing worn by the men was practically doubled and has continued to increase. Long trousers, a shirt, and some sort of a coat to use at the stations and coming out of the mine are worn by the majority. The second noted change was a decrease in the number of men coming to and from the stations for drinking water. The third, but not least important change produced by the fans was that tramming, especially, speeded up and the tons per man increased. However, at this time there were other improvements and changes made in the mine, and it is impossible to say to what extent the mechanical ventilation has helped increase production. With the fans in operation there is a better spirit evident in the men. They appreciate the improved conditions and consciously or unconsciously have shown their appreciation in their work. At any rate, they are capable of doing more and better work than they were before the installation of the fans. Now, while they perspire freely, there is not that completely fagged-out feeling previously experienced when the shift was only half over.

After the fans had been in operation a short time it was necessary to change some of the doors in the especially damp places, for they had warped out of shape. In making the new doors the 1-in. boards on one side were laid crossways, and the 1-in. boards on the other side were laid lengthways. This apparently corrected the fault in the construction of the doors, for no trouble has been had with them since that time. It was found that it was impossible for the pipe men to work on the sand-fill pipe lines in the No. 45 raises with open lights. Enclosed lights were purchased, and while these are satisfactory as far as the light is concerned, it is impossible for the men to work with any sense of security in these raises because of the high velocity of the air passing through them. Consequently another line of raises from the 1,200 level to the surface is being driven, and these will carry the sand fill pipe lines. When this is changed the ventilation raises will be free of travel except in an emergency, when they may be used as manways.

While the bulk of the production comes from the lower levels, nevertheless there is occasionally (*Continued on page* 510)

U. S. Bureau of Mines Photo

STOPING METHODS *in* MICHIGAN COPPER LODES

By ALBERT MENDELSOHN *

Mining Methods Have Changed But Little In Last 15 Years, But Notable Changes Have Occurred In The Detail Of Stoping And In Organization Of Work — Important Modifications In Stoping Methods In This Territory Outlined

THE Michigan copper-bearing lodes now being mined extend, in many cases, for miles along the strike, with only few offsets due to faulting. The lodes dip at angles of 32° to 70°—the dip of any one lode being fairly constant from surface to great depth, where the dip may flatten. The lodes are being mined now an average width of 5 to 20 ft., the width mined in any one lode being fairly uniform, although the lode may often widen to as much as four times this width, especially at points of intersection with "crossings." The copper occurs as native copper, in very small particles, in "shot" form and in larger "masses." These "masses" may be many tons in weight, and often must be cut up by chisel and twist drill into proper sizes for handling. In some of the lodes the copper is fairly uniformly distributed in the lode; in other lodes it occurs in patches. The rock is hard. Timber props are used to support local "loose" only. Timber support is used as part of the method of stoping on the conglomerate lode only.

The lodes of this district are being stoped out today by the same methods that were used more than 15 years ago. The first edition of Peele's "Handbook of Mining Engineers," published in 1918, contains complete and accurate descriptions and sketches of the mining methods still in use in this district in 1928; and anyone more than casually interested in the subject of this article will find the mining practice on the Calumet & Hecla Conglomerate Lode described in Section 10, Articles 17 and 38; the practice on the various amygdaloid lodes described in Section 10, Article 40; and the Baltic Mining Method described in Section 10, Article 64, of Peele's "Handbook."

There have been notable changes in the detail of stoping and in organization of the work. One of the important results of these changes is illustrated in the following table, which gives the pounds of copper per ton of rock stamped for the important lodes for the years 1927 and 1916:

POUNDS COPPER PER TON OF ROCK STAMPED ("YIELD")			
	1916	1927	
Lode 1.....	13.4	24.5	
Lode 2.....	20.8	29.0	
Lode 3.....	21.0	32	(Approximate)
Lode 4.....	35.9	39.9	
Lode 5.....	29.9	36	(Approximate)
Lode 6.....	13.6	20	(Approximate)

These figures are from representative mines on each of the lodes. They illustrate clearly the change toward closer "selection" of the rock mined or broken. This "selection" and the consequent increase in "yield" are the result of the difficult and painstaking task of "following the copper" and breaking a minimum of barren rock without increasing costs of operations.

While this increase of the richness of rock stamped could be easily accomplished in a mine which had fairly reliable assay maps and sampling organization and control, such a situation does not exist in the copper mines of Michigan. The lodes of this district have never been successfully sampled; the occurrence of the native copper is such that it does not permit of satisfactory sampling. In this whole district there is not an assay map of any mine made up by the usual sample and analysis method. The value of the ground to be mined is gauged entirely by eye by the man in charge of underground work. Mill runs, made to determine the richness of rock mined, are usually made on no smaller unit than the entire production of one hoisting shaft.

So after making due allowance for the improvements in extraction and recovery at the concentrating plants (such as fine grinding a larger portion of the rock stamped), the increase in "yield" of rock is found to be the result mainly of work in the mine.

Contrasting present with past details of stoping operations in order to discover the reason for this increase in "yield," we find for the year 1916 the following practice to have been pretty general in the copper country: Drifts were being driven at fairly good speed by first-class miners, whose contracts called for pay at a certain price per linear foot of drift. The miner's best friend on such a basis was a damp slip against the hanging (or foot) trap to which his cut-in holes would break freely; and it was difficult for a captain or shift boss to separate the miner from such a slip—especially when the captain himself found it pleasant to talk to his competitors and superiors about the fast drifting his men were making. So as long as the drift showed some copper, the miner was generally permitted to drift in that part of the lode where he could make the most speed. The stoping contracts were generally on a ton or cubic foot basis; and the miner was more than tempted to widen his stope, breaking freely into the foot, in order to make tons, regardless of the copper content of those tons. And very often the bosses were quite aware of what was taking place, but they, too, in keen competition with each other, were pressing for "dirt" and were willing to take anything and everything to increase their "hoist." At the same time each boss had one or two rich stopes which he forced to the limit in order to keep the average "yield" from falling too low. In some mines the captain in turn was being pressed by the ambitious hope of "dollar rock"; and

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in aiming at that figure as a production cost was willing to compromise with the pounds of copper in the ton he expected to produce for $1.

Today the drift miners try to "follow the copper." If the drift becomes "lean," test holes are drilled or crosscuts driven to foot and hanging, to prove the ground. No drift miner likes such a procedure—he loses time and money by it—so he takes pains to keep his drift in good ground. In the stopes the miners, in many mines, are on a "per foot of hole drilled" contract; a hole drilled into the foot trap is ordered "not to be blasted" by the captain and the miner is not paid for such useless holes. Thereafter the miner drills his holes in copper rock only. Not only does he keep away from trap, but he avoids vein rock on the foot which does not appear to carry copper. Consequently, lodes which in 1916 were mined 10 to 12 ft. wide, are today mined only 7 to 9 ft. wide. On the Baltic Lode the miners who are on contract based on total tons of rock broken are also under contract to pick the rock after breaking, separating copper rock from barren rock. They are also under contract to fill their stopes with waste rock, part of which is the discard from the rock they have picked. So with these miners, too, the advantage lies in "clean" work. In other mines rock too lean to mine is left in the stope in the shape of irregular pillars.

In the Copper Range Co.'s mines on the Baltic Lode, on account of the occurrence of copper in bunches, the width of the lode, the 70° dip and a rather poor hanging, the method in use for over 20 years has been to "pick" the rock after breaking, throwing down to the chutes all rock showing any copper whatsoever, and discarding rock which showed no copper, leaving this barren or "poor" rock in the stope as stope filling to support the hanging. This practice has been continued, but with the addition to organization of inspectors who examine the copper rock cars for large pieces of barren rock and look over the piles of discard for pieces of rock containing copper. This inspection serves as a check on the supervision by the regular production organization.

All of these changes have probably saved millions of tons of barren and unprofitable rock from being handled and shipped through the stamp mills, at a saving for every ton so left in the mine of from 60 cents to $1, the present cost of tramming, hoisting, crushing, transportation and milling.

Some of the important modifications in the details of stoping methods in this district are as follows:

At the Champion Mine, operating on the Baltic Lode, all stoping is now done on the incline cut and fill system. Heretofore this mine was worked by the Baltic Mining Method (Peele, Section 10, Article 64), using horizontal cut and fill. Organization in the stopes has been completely changed; the old method of having one group of men to mine, one group to pick, one group to build ore passes, one to fill stopes, etc., each waiting its turn in the cycle of operations, is no longer practiced. Each stope in the mine now has a miner and helper who do all the work in that stope—they break the rock, pick it, build up the ore passes, and fill their stope, and do all the propping necessary in their working place. This change in organization has resulted in an increase in production from the stopes due to elimination of the time that was previously lost between the operations. It also has developed better cooperation between the shifts; and the men working in the same places continuously, fixes responsibility and also tends toward safer work. The change from horizontal to inclined cut and fill permits the use of gravity and has decreased the handling and filling costs. Apparently also the sloped backs are left in safer condition for men to work under than were the horizontal. Taking out the 35-ft. floor pillars on the retreat is still done as described in Peele. Building of rock "dry wall" haulage levels has been discontinued because of high labor charge; the poor rock is picked out as before in the drift-cutting out, but it is not built up into walls. Instead, timber sets (legs and caps) of 15-in. hemlock, peeled, are set up at 6-ft. centers and well lagged with good-grade split cedar lagging.

At the Calumet & Hecla Conglomerate branch scrapers in the drifts are coming more and more into use. The advantage of this kind of mucking in this deep mine where rock temperatures are high is considerable. Larger capacity scrapers are also used to handle stope dirt, in a manner which apparently has many advantages. This mine is on the retreating (long-wall) method, and the ground inside the stope being worked is not kept open. The rock broken in the stope slides down the foot-wall side of the stope and is allowed to fall directly on the level. There are no chutes or elevated sollars; the rock falls to the level and is scraped up a permanent, timbered incline into the tram cars. The absence of chutes and sollars also aids the free passage of air up through these warm stopes.

At the Ahmeek mine much has been done by closer supervision of the rock broken and of breaking costs. The lode is mined considerably narrower than before, and the rock stamped shows a corresponding increase in yield. In parts of this mine the dip is so flat that rock will not flow by gravity to the chutes. These chutes are constructed under "pigeon holes" blasted through the rock arch which is left standing over the haulage level. To help the rock down the stope, large capacity scrapers have been installed to drag the rock to the chutes, where it spills into the large tram cars. To support the hanging, so-called "rib" pillars are left in the stopes at regular intervals; these pillars are parallel to each other, running up and down the stope, so as not to interfere with scraper operation, and at judicious intervals are cut through by the miners to aid ventilation. They are recovered subsequent to regular stoping operations, as is also the arch of rock over the level. The Mohawk mine is on the same lode as the Ahmeek, and in general their method is the same.

At the Isle Royale mine the dip is such that the broken rock finds its way by gravity to the chutes, permitting a shrinkage method. At this mine the copper occurs in patches, and much attention is given to avoiding the breaking of the intervening barren patches of rock. Consequently the chutes are sometimes built under pigeon-holes through an arch of barren rock, and sometimes, where the rock over the level was copper and has been removed, they are built of timber and lagged. In stoping, the miners must take pains to avoid breaking poor rock; and pillars of apparently barren rock of irregular shape are left at irregular intervals wherever they occur.

In the Isle Royale mine, as at most of the other mines in the district where they have succeeded in confining stoping work to the copper-bearing part of the lode only, efforts were taken to prevent the increase in mining costs due to this more restricted breaking. The best machines are bought, air pressures are boosted to about 90 pounds, the miners are carefully supervised and their contracts carefully set to get best results. Generally speaking, stoping costs in the mines of this district have been reduced in part by the changes made in details of operation, some of which are described above, and in part by better organization and better supervision of all details of underground work.

SOLVING VENTILATION PROBLEMS BY MECHANICAL MEANS

(*Continued from page* 490)

which reduces the humidity content, and the air currents carry off the small particles of fine dust, which, unlike the larger particles, do not settle immediately but remain in suspension for many hours. If the air currents are strong enough, and the passageways properly arranged, a large amount of this fine dust is carried through the upcast shafts and thus eliminated from the workings.

COAL

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Editor

Practical Operating Problems of the Coal Mining Industry

ARE PERMISSIBLE POWDERS NEEDED *where* EXPLOSIVE GAS *is* ABSENT*

By T. W. GUY†

Most Accidents Due To Use Of Explosives Are Result Of Ignorance, Carelessness And Recklessness—Results Depend Not So Much On Permissible Explosives, As The Ability And Determination With Which The Mine Management Train Their Personnel In Safe Methods

THIS question should be considered first from a standpoint of safety, and second of efficiency.

SAFETY

The U. S. Bureau of Mines, by adopting a permissible standard and encouraging the development and use of safety powders, has done much to reduce the necessary dangers due to the use of explosives in our coal mines. Their experiments have proven conclusively that the permissible powders are much safer than dynamite or black powder when compared as a potential agency for igniting explosive gas or coal dust. Unfortunately, however, most accidents due to the use of explosives are the result of ignorance, careless or reckless use, and probably it would not be far from the truth to say that the permissible use of explosives is even more important than the kind of explosives used.

While the U. S. Bureau of Mines and the various state departments of mines have done much to meet this difficulty, after all, they can only point the way, and the results depend on the ability and determination with which the individual mine managements train their personnel in safe methods.

Having all shots loaded and fired by trained men using permissible explosives, and when there is no one else in the mine, is probably the safest method of shooting coal, provided the cuttings are loaded out as required by law; that shots are not fired in quick succession so that one shot is fired into the dust cloud raised by the preceding; that transportation of explosives in bulk is properly safe-guarded, etc. At best, however, this plan usually means considerable sacrifice in preparation and labor efficiency. All the other plans in use ranging between this and allowing each miner to shoot at will, presents many dangers to be avoided and difficulties to be overcome. Conditions vary widely in the different fields and in different mines in the same field. Likewise, there is wide variation in practices and in opinion as to what is safe and what is dangerous practice. In some states, no one would think of shooting coal from the solid except with permissibles, if at all, while in another within the last few years, it was being regularly shot from the solid in gaseous mines with charges up to 25 pounds of black powder in a single hole.

During the past 20 years, approximately 2½ percent of the mine fatal-

* A part of the general discussion carried on by The Mining Congress Journal since January, 1928, concerning necessity for the use of the so-called short-flame explosives as against the use of black blasting powder.

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U. S. Bureau of Mines photographs.

ities in this country have occurred in mine explosions which were initiated by black powder or dynamite setting off explosive gas or coal dust or both (the exact number of each case is not known). This is approximately one-fourth of the total killed in mine explosions due to all causes. During the last few years, deaths caused by explosions initiated by black powder or dynamite have decreased about 30 percent, while those due to explosions initiated by other causes have remained about the same. The reduction in deaths in explosions caused by black powder and dynamite is probably due to some extent to the more general use of permissibles in place of black powder in gaseous mines; although statistics indicate that there is also an increase in the use of dynamite, particularly in the anthracite mines. The wider use in recent years of electric wires and equipment in mines has contributed materially to explosions from causes other than explosives. The development a few years ago of black powder in stick or pellet form, which may be shot with electric squibs, has reduced materially the hazards due to handling black powder, although, of course, the long flame remains.

The writer believes that only permissibles should be used where gas is present or even probable, but that black powder in pellet form may be used in many mines with little or no danger of initiating a dust explosion, provided reasonable charges are used and tamped with clay or rock dust.

About 5 percent of the total mine fatalities in the United States are the result of individual accidents due generally to careless or improper use or handling of explosives. These account for from 100 to 125 deaths annually besides probably twice as many permanent disabilities. Black powder has been responsible for a large number of these. Opening powder cans with steel tools; sparks from lamps or pipes while handling black powder; blown-out shots and delayed shots, generally caused by carelessness or shortening the squib are some of the causes of accidents with black powder which have been practically eliminated by changing it from granular to the stick or pellet form. A great many accidents also have been caused by careless handling of permissibles and of the blasting caps or exploders which must be used with them. On account of the permissible powders being quicker, miners frequently shoot their holes without properly tamping or stemming them using a heavier charge of explosives in order to break down the coal. If use of fuse is allowed, they frequently add "using short fuse" to their other abuses of the permissible explosives, thus causing many serious accidents.

Efficiency

In a comparison of the efficiency of permissibles with black powder, we must consider primarily the resulting preparation of the coal. There are many different brands of permissible explosives available, and each manufacturer makes a large number of permissibles varying in bulk and in rate of detonation and also in the size of sticks. Experiments show that the different permissibles will give widely different results, and that a certain type of explosives will give much better results in a given mine than other types. Experiments show that in a group of mines in the same seam, best results can be had by using different permissibles where there is even a slight difference in the conditions, and as a practical proposition, it is generally conceded that the best suited permissible does not give as good quality or quantity of lump as black powder. The difference in value of lump and slack coal for the past several years has averaged in the neighborhood of $1 per ton. This means that each 1 percent of the coal made into slack reduces the average market value of the entire output approximately 1 cent per ton. The writer's experience leads him to believe that the reduction in lump due to the use of permissibles as compared with black powder will generally run between 5 and 10 percent when equal care and skill is used in shooting with both explosives. A further important item in preparation which is seriously affected by the explosive is the problem of cleaning the coal where there are bands of impurities in the seam, or where there is a soft roof or bottom. In such cases, other things being equal, the permissible powder usually results in greater difficulty of separating these impurities. Also, in addition to these disadvantages which affect the preparation, there are many mines where the use of permissibles would cause considerably more roof trouble, and frequently heavy expense, due to the fact that the permissibles would shatter the roof to a greater extent than black powder. In comparison of the cost of explosives in all of the experiments which the writer has made, a greater number of cents worth of permissible explosive was needed to shoot a cut than was required of black powder. Of course, the quantity of each required depends to a large extent on a number of conditions such as thickness and location and nature of partings in the seam; the location and depth of the undercut, and the thickness of seam, etc., and to a large extent on the placing and loading of the holes. If we save a little powder by using more holes, we have increased the cost of drilling and the cost of exploders which will usually more than offset any saving possible in the explosives.

To sum up, I believe that from a safety standpoint, there are many mines in the country where flameless powders are not needed because there is no explosive gas, and because coal dust can be rendered inert by proper rock dusting, thus practically eliminating the danger of coal dust explosions initiated by explosives or from any other cause as well; that fewer individual accidents will occur among a given number of men using black powder in pellet form than if using permissibles because of the exploders which must be used with permissibles. (If fuse be used, many additional hazards are introduced.)

The cost of the necessary rock dusting, and of careful supervision of the tamping and use of pellet powder required to make it safe in non-gaseous mines would be much less, in most mines, than the reduced value and increased cost of the product if permissible powders were used.

However, each operator, in addition to complying with his mining laws, should study carefully what explosives and what methods are best suited to his conditions from a safety and a cost and preparation standpoint, watching continually the changes in conditions in his mines, development of improved material by the manufacturers and improved methods by other operators. He should also take full advantage of the valuable information and assistance to be had from the Bureau of Mines, his State Department of Mines and from the technical representatives of the explosive manufacturers.

USE OF "TOUCH PAPER" FOR BLASTING CONDEMNED

The hazards involved in the use of the so-called "touch paper" in firing blasts in gassy coal mines are pointed out by the United States Bureau of Mines in Information Circular 6067, recently issued.

Touch paper is usually made at the mine by thoroughly soaking ordinary cardboard about one-sixteenth inch thick in a solution of water or vinegar and saltpeter. The impregnated cardboard is dried and cut into strips about 1 in. wide and used to light the fuse employed in firing the blast. The glowing touch paper constitutes a possible open light which may become the origin of a mine explosion.

The safer method urgently recommended by the Bureau of Mines is the firing of one shot at a time electrically with a permissible single-shot blasting unit, using a detonator of suitable strength. The bureau has approved for permissibility eight single-shot blasting units.

SELECTION *of* EXPLOSIVES *for* COAL MINING*

By ROBERT SCHLESS †

Bureau of Mines pendulum friction device for testing the sensitiveness of explosives

U. S. Bureau of Mines Photo

However Remote Danger Of Igniting Gas Or Dust, It Is Ever-Present Menace, Rendering Use Of Nonpermissible Explosives Potentially Dangerous At All Times—Explosive Engineering Has Developed Methods Of Getting Results With "Permissibles" As Economically As With Black Powder

TWO of the most important problems of mining are the selection of explosives and of blasting methods. The coal-mining industry involves a special condition not common to any other mining. It is the inflammability and explosibility of fire damp and of coal dust which introduces a dangerous condition into the coal-mining industry in addition to the risk connected with any mining. The use of explosives, which is essential under present conditions, involves the danger of igniting the gas or coal dust or both. These ignitions result in disastrous explosions.

The strong demand for coal of large dimensions creates another serious problem, the successful solution of which hinges in a great measure on the proper use of proper explosives.

It is well known that coal seams vary widely as to thickness, hardness, presence of bands, crevices, etc. Even mines within the same seam often vary to a considerable extent.

Each mine executive has his own conditions and problems, among which the blasting problem is one of the most important. Consequently his explosives and blasting methods have to be chosen so as to fit these particular conditions.

However, no matter how varied his choice, it will be governed by certain fundamental requirements. The most important of these requirements is safety, and this consideration, if logically applied, should lead to the elimination of such explosives whose flames are the most frequent cause of gas and dust ignitions and explosions. Fortunately, it was possible to devise explosives comparatively safe in this respect and to develop and improve them to the extent of meeting other requirements which explosives should answer, namely, bringing down coal at a reasonable cost and, besides, where it is necessary, in large sizes. These explosives, officially termed "permissible," possess distinct characteristics in which they differ from the other main classes offered for coal mining—black blasting powder, granular and in form of pellets, and the various grades of dynamite.

Thus, from the standpoint of safety in coal mines, explosives belong to either of two classes—permissible or nonpermissible. Following are their properties:

Permissible explosives are sometimes termed short-flame or cool-flame explosives. These terms very properly lay emphasis on the flame characteristics of these explosives, rendering them comparatively safe in the presence of gas and coal dust.

The term "permissible" is the official name given this type of explosives by the Bureau of Mines, and involves a definite set of conditions they should satisfy on being subject to standardized tests at the Bureau's experiment station.

These tests, in addition to ascertaining the behavior of explosives in the presence of gas and coal dust, cover also the determination of density, strength, velocity, quantity of poisonous gases developed on detonation, sensitiveness to friction, length and duration of flame, propagation sensitiveness and chemical analysis. Information regarding the results of these tests is furnished the explosives manufacturers, who are supposed to comply with them within certain, so-called tolerance limits, in preparing their product.

Results of some of these tests are also given out for general information in the official lists of permissible explosives published from time to time by the Bureau of Mines.

These lists are intended for guidance of the users in ascertaining the identity of explosives offered them by the manufacturers and claimed to be permissible, and for acquainting the users with the main features of these explosives, such as strength, expressed as "unit deflective charge," rate of detonation or velocity, smallest permissible diameter, characteristic ingredient, poisonous-gases classification, and weight of a standard size (1¼ x 8") cartridge.

Guided by the above data, the prospective user before deciding on a certain permissible explosive undertakes a series of comparative tests, the outcome of which decides his choice.

The Bureau of Mines laid down a set of conditions, observance of which is imperative if it is desired to derive a benefit from the features of the explosives which render them permissible. If one or more of these conditions are disregarded, the explosives cease to be permissible.

These conditions are as follows:

(1) That the explosive is in all respects similar to the sample submitted by the manufacturer for test.

(2) That electric detonators are used of not less efficiency than those prescribed, namely, those consisting by weight of 80 parts of mercury fulminate and 20 parts of potassium chlorate (or their equivalents).

* Part of discussion carried on by The Mining Congress Journal on "The Use of Permissible vs. Black Blasting Powder."

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(3) That the explosive, if frozen, shall be thoroughly thawed in a safe and suitable manner before use.

(4) That the quantity used for a shot does not exceed 1½ pounds (680 grams), and that it is properly confined with clay or other noncombustible stemming.

After an explosive has passed the required tests and its brand name has been published in a list of permissible explosives, it is not used in a permissible manner if one or more of the following conditions prevail:

(1) If stored under improper conditions until it undergoes a change in character.

(2) If used in a frozen or partly frozen condition.

(3) If used in excess of 1½ pounds (680 grams) per shot.

(4) If the diameter of the cartridge is less than that designated in the column "Smallest permissible diameter."

(5) If fired with an electric detonator of less efficiency than that prescribed.

(6) If fired with fuse.

(7) If fired without stemming.

(8) If fired with combustible stemming.

(9) If fired in the presence of a dangerous percentage of fire damp.

(10) If the shot is a depending shot or is bored into the solid or has a burden so heavy that the shot obviously is liable to blow out.

Needless to say that not only during the preliminary tests but also in later use these conditions should be observed.

Thus, the term "permissible explosive" involves not only a certain class of explosives but also certain broad lines of blasting and mining methods.

Blasting and mining methods are of a great importance in relation to efficiency and lump-coal producing qualities of explosives, as results obtained from a certain explosive differ in accordance with conditions under which it is used.

Therefore the subject of selecting a permissible explosive for a certain mine is closely interwoven with the selection of blasting methods, and in this article it is thus appropriate to treat both subjects in their relationship.

As has been pointed out, conditions in mines vary to a great extent, and blasting methods will vary accordingly, but certain general rules should be observed to obtain efficient results:

All rib holes should be drilled parallel to the rib, coal should be undercut and all holes should stop short of the back of undercut never extending into the solid to avoid wasting explosives and possibility of blown-out shots. Holes, as a rule, should be drilled as flat as possible. All coal cuttings should be removed from the undercut to obtain clear space in which the coal can break down properly and the bore holes cleaned out to avoid accumulation of coal dust between cartridges of explosives. It is well know that if coal dust finds its way between cartridges of permissibles a small amount of it may stop propagation of a detonation.

It is of utmost importance not to overcharge the boreholes to avoid wasting of explosives, shattering of coal, and producing excessive amount of smoke.

The necessity of proper loading of shots can not be overemphasized. Local conditions have considerable bearing on the method of loading. As a rule, it is recommended to concentrate the charge in the back of the hole and tamp the hole tight to the mouth in hard and high coal. On the other hand, in soft and thin coal it may be advisable to have an air space around the explosives cartridge; in other words, to use a cartridge of a diameter smaller than the diameter of the borehole, and in tamping the shots to place the tamping in such manner that it will be only lightly compressed for some distance from the charge and then tamped solidly to the mouth. Air spacing between the cartridge and stemming secured by means of a copper air spacer is also a practice sometimes recommended under these conditions, as well as rock stemming, the idea being to form a "buffer" to absorb the severe shock produced by the detonation and to cause a more gradual expansion of the gases. Combustible stemming, such as coal dust, should not be used under any circumstances.

As examples of practical applications of the above outlined principles, which resulted in increased efficiency and in larger quantity of lump coal, we will refer to the work of Tiffany and McKittrick outlined in Bureau of Mines report of investigations, serial No. 2697, and to coal-mining investigations conducted cooperatively by the Carnegie Institute of Technology, the Bureau of Mines, and the advisory board of coal-mine operators and engineers, published in Bulletins 11 and 19 of the institute.

This work is concerned with the study of factors affecting the production of lump coal in mines representative of the various coal beds, Bulletin 11 covering tests by Tiffany and Nelson in the Naomi mine, Pittsburgh seam; Bureau of Mines report relating to No. 6 coal bed of the Southern Illinois field and Bulletin 19 outlining work by Tiffany and Lubelsky in Banning No. 2 mine, Pittsburgh coal bed.

These investigations are typical of the work connected with the selection of blasting methods and explosives for any coal mine and, although different results may be arrived at and different conclusions drawn under conditions other than those investigated, the general plan and method of getting at the solution of the problem may be generally applied, and this reference, therefore, may best serve our purpose of further developing this discussion.

By varying the blasting methods at the Naomi mine an increase of 7.4 percent of 1¼-in. lump coal was accomplished with a corresponding decrease of 31 percent in explosive used. Essentially the improvement was obtained by air spacing with snubbing after the coal has been undercut.

Investigation in the Southern Illinois field was conducted in a mine producing 4,000 tons per day. Accomplishment of this investigation was an increase of 2 percent of 6-in. lump coal based on the entire production. It was found that poor blasting efficiency resulted from improper placement of holes, overloading, and insufficient stemming. Cartridges used were 1¾ by 6 in. and the explosive had a medium rate of detonation. As a result of tests, a standard method of blasting was adopted eliminating the drawbacks of the old method and cartridges of 1¼-in. diameter were introduced, thus providing air space around the cartridges. Experiments with permissibles of various rates of detonation showed that in this case the rate did not have any considerable influence on the amount of lump coal, the high rate explosive, however, shattering the coal somewhat more.

Investigation in Banning No. 2 mine has resulted in the increase of 8½ percent of 1¼-in. lump coal. In this investigation a more detailed study was made of the selection of a permissible explosive best suited for the conditions and definite conclusions were arrived at, as per following quotation:

"Although frequently it has been stated that a slow explosive is the most desirable for shooting in coal, these tests show that for the particular coal tested the slowest explosive did not give the best results. In using the slowest explosive the gases escaped through the openings, which, owing to the low resistance of the coal, were easily made along a few bedding planes without acting to any great extent upon the rib and the back of the cut. In using an explosive having the other extreme of rate, the local shattering effect was too great and the shot did not succeed in opening enough of the coal to make the mining easy. It is probable that coals of different physical texture require explosives of different rates for the production of the maximum lump coal. In considering the physical texture of coal, the ease with which the bedding planes are opened, the regularity of the face and butt cleats, the parting along the draw slate, and the hardness and uniformity of the coal are important factors for study."

Velocities of explosives used and results obtained were as follows:

Explosive	Rate of detonation (m. p. s.)	Lump coal: Tight shot, percent	Butt shot, percent	Total of shots, not including bug-dust, percent
A	2433	64.6	69.0	66.1
B	2262	61.2	61.2	61.2
C	3144	60.7	66.2	62.8
D	3020	63.2	65.0	63.7
E	2869	65.0	71.9	67.1

In addition to the shooting down of coal, a certain amount of rock blasting has to be done in coal mines, and some permissible explosives have been designed to meet these requirements. The plastic or gelatin permissibles are also intended for this purpose and are especially fit for wet boreholes, being the best known water-resisting explosives. The fact should never be lost sight of, however, that in the majority of permissible explosives used at present belonging to the ammonium nitrate class, their water resistance is low, and disregarding this condition is the most frequent cause of deterioration of permissible explosives. Nitroglycerin permissibles occupy a medium position between gelatin and ammonium nitrate permissible explosives in regard to moisture resistance. Regarding fumes, on the other hand, the ammonium nitrate class approaches the gelatin explosives, which are considered best in this respect.

Permissible explosives are comparatively safe for transportation and storage, and fewer accidents result from them than from other explosives.

Turning now to the non-permissible explosives and considering them, first, from the standpoint of safety of handling, we find the granular black blasting powder put up in metal kegs to be the most hazardous—a number of accidents occur from the metal kegs coming in contact with trolley wires while being carried or hauled in mines, and in opening the kegs by means of picks or other metal tools. In pouring the loose powder from kegs for cartridging some dust is raised which may be ignited by a flame of an open lamp.

Pellet powder and dynamite being put in cartridges and loaded in wooden cases are safer to handle than granular black powder, and from this standpoint pellet powder and ammonium nitrate dynamite are safer than the higher grades of dynamite.

As to moisture resistance, granular black powder is the poorest. Pellet powder and ammonium nitrate dynamite are better in this respect, but still are considerably affected and have to be handled with great care in the presence of moisture. Nitroglycerin dynamite and especially gelatin are best adapted to moist and wet conditions.

Granular black powder produces a large amount of smoke of a very irritating nature. Smoke from pellet powder is not so offensive, but ammonium nitrate and gelatin dynamite are much better. Nitroglycerin dynamite occupies a medium position.

Concerning performance, black powder develops its action much slower than all other classes of explosives. It belongs to the class of the so-called propulsive, deflagrating or low explosives, whereas the others are detonating or high explosives.

For this reason opinion is often expressed that black powder will not shatter the coal no matter how it is used.

This statement, however, is greatly exaggerated. Referring to instruction issued by manufacturers of black powder, we will find a set of rules recommended to avoid shattering and pulverizing of coal which in their nature compare with precautions that have to be taken when permissible explosives are used.

It is true that overcharging with granular and pellet black powder does not pulverize the coal to as great extent as overcharging with permissible explosives, but overcharging is not an unavoidable evil, and, as shown above, charges of permissible explosives can be kept within limits close enough to eliminate waste of explosives and undue shattering of coal.

Hand in hand with this proper gauging of shots should go the other safe practices enumerated before.

When all necessary precautions are observed and proper blasting methods used, permissible explosives produce lump coal in quantities favorably comparing with black powder.

Cost per ton of coal mined with permissible explosives also compares favorably with black powder.

Nitroglycerin and ammonium nitrate dynamite and gelatin are too quick in their action for blasting in coal, but are suitable for rock blasting in coal mines from the standpoint of their execution but not from that of safety. Permissible explosives, especially those of plastic consistency (gelatin permissibles), are perfectly adapted for this work and are comparatively safe.

With good blasting practice the cost per ton of rock removed by means of gelatinized permissible explosives is about one-half of the cost of removing it by means of dynamite.

Conclusion

The facts are, then, that the explosives manufacturers are in position to supply the coal-mining industry with specially designed explosives, called "permissible," comparatively safe in the presence of fire damp and coal dust if used under conditions which it is reasonable to expect should prevail in all coal mines. Their safety has been proven not only in the United States but also in coal-producing countries the world over.

Explosives engineering has developed methods of getting results with these explosives as economical, or more economical, than are ordinarily obtained with granular or pellet black powder and with dynamite in the respective classes of work for which they are adapted in coal mines.

However remote the danger of igniting gas or dust in some mines may seem, it is an everpresent menace, rendering the use of non-permissible explosives potentially dangerous at all times.

What should be the unanimous choice of the coal-mining industry? The answer is self-evident.

BETHLEHEM STEEL HOLDS FIRST AID MEET

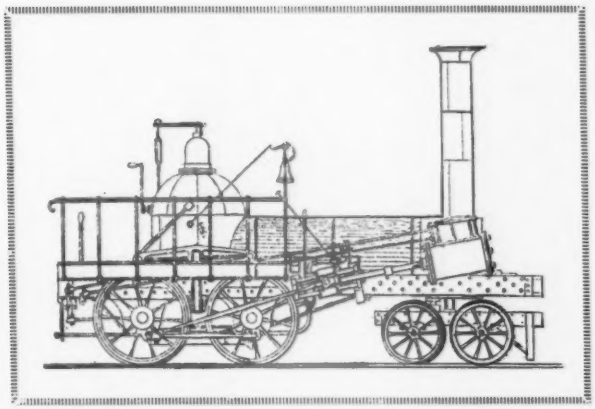
Safety education of employes of the Bethlehem Steel Corporation helped to reduce lost-time accidents at Bethlehem plants 54 percent in the last 10 years. This improvement was announced in connection with the company's Fourteenth Annual First Aid and Mine Rescue Meet, which was held June 22 at Sparrows Point, Md.

Employes from all the Bethlehem Steel plants and mines competed in a contest of efficiency in first aid and mine rescue work. Cash prizes were awarded by E. G. Grace, president of the company.

Bethlehem now trains about a thousand men in safety and first-aid every year. More than 8,000 employes have received an intensive course of instruction in this work during the last 12 years.

This First Aid Meet, which represents the final step in the graduation of employes from the corporation's course of instruction, is only one feature in a safety program which includes also a gold award accident-prevention contest. In this contest three prizes of $1,000, $500 and $250 in gold are awarded quarterly to three groups of employes showing the greatest reduction in time lost due to accidents.

Marked improvement in accident prevention was effected by the employes during the first quarter of 1928. Bethlehem as a whole has improved its best previous record by 17.8 percent. The steel plants alone bettered their safety record by 44 percent.



The first locomotive with equalizers, built by Eastwick & Harrison, 1837

IMPORTANCE *of* EQUALIZATION *in* LOCOMOTIVE DESIGN

By WILLIAM A. AUSTIN *

Equalization As A Principle Of Locomotive Design Has Adapted The American-Built Locomotive To All Kinds Of Service In All Parts Of The World, And Has Found Favor With European Locomotive Builders

EQUALIZATION as a general term, no matter how applied, always indicates a steadying influence and a leveling of inequalities. Applied to a locomotive design, the term stands for a system of weight distribution originally peculiar to America and which has given American-built locomotives an enviable reputation for steadiness and ease of operation over all kinds and conditions of roadway. To fully appreciate its importance it is necessary to briefly review the early history and development of the railway.

Vehicular traffic has at all times been dependent on conditions of roadway and some system of wheel suspension which would adjust itself thereto. The weight of the vehicle with its load must be so distributed over its points of support as to maintain safely the center of gravity of the entire mass. Considering the points of support for a moving load, it is obvious that while a single point will adapt itself to all ground conditions, it lacks balance in all directions. Two points of support will also adapt themselves to most irregularities, but the combination lacks balance either longitudinally or transversely according to its disposition with relation to the road. The correction of balance for both these systems early adopted auxiliary supporting mediums to approximate the effect of a tripod. Consider the wheelbarrow; its one revolving support is balanced in triangular effect by the two supporting handles. Likewise, the two-wheeled cart is balanced triangularly by the single support resting on the back of its animal motive power. In ancient times these two types of triangularly balanced vehicles operated over the roughest of roads, and today they are still standard in their own peculiar province. The tripod as a steady support is always supreme, and its adaptation to the support of moving loads is in logical sequence.

Early railroads originated from wagon ways whose origin can probably be traced back to the sixteenth century. A description of these in 1676 states that "the manner of carriage is by laying rails of timber, * * * exactly straight and parallel, and bulky carts are made with four rowlets fitting these rails." These wooden railways and the later iron rails were all developed to decrease the irregularities of surface and to offer a better roadway in a comparatively simple and economical manner. Naturally, the first of these were comparatively crude and rough, but they suited better the four-wheeled vehicle because they provided a more nearly level surface. Colliery cars were, and are today, of short wheel base, adapting themselves well enough to minor irregularities and proving satisfactory with their comparatively light loading. Always, however, the four individual points of support have a tendency for individual "unloading," just as one leg of a four-legged table lifts on an irregular footing and endeavors to adjust itself to a triangular balance on the other three legs.

With the invention of the locomotive the problem of support and distribution became more complicated. Here heavy weights were necessary to provide adhesion for tractive effort and they proved most destructive to the rails in spite of the individual spring suspension provided at each journal. This spring suspension allowed any individual wheel to adjust itself to a depression in the rail, but at the expense of "unloading" a part of the weight carried with consequent shock on the other three. Early locomotive history is full of references to destructive weight and the failures of locomotives therefrom.

The first engine imported to America from England in 1829 was the Stourbridge Lion, ordered by Horatio Allen for the Delaware & Hudson Canal Co. This engine attracted great attention at the time, but proved so destructive to the rails that it was practically never used. In 1832 it is recorded of the New Castle and Frenchtown Railroad that: "A locomotive engine of the latest pattern, made by Robert Stephenson, has been imported by the company. * * * The weight of the engine is not adapted to a railway of slender proportions, composed of timber and light rails." At about the same time an English traveler wrote from America: "The immediate obstacle to the use of locomotives in this country arises from their great weight, which crushes the iron rail into the wooden runner which supports it."

Baldwin's first engine, Old Ironsides, was commented on as having "principal superiority over any of the English ones in its light weight." From such reports it would appear that the early American railways were probably lighter in weight and foundation, and rougher in alignment than their English prototypes.

The significance of the comment on Old Ironsides is that no improvement in suspension had been provided, merely a lessening of weight. Such condition could not long obtain, because weight was needed for adhesion, and without it increased traffic and increased loads were not possible under the then existing plans of engine builders. The first attempt at the better weight distribution included the adoption of a swiveling bogie truck, which gave the desired three-point suspension. Baldwin's second engine, the E. L. Miller (1834), was on this plan, and the weight showed an increase of

* Consulting Engineer, The Baldwin Locomotive Works, Philadelphia, Pa.

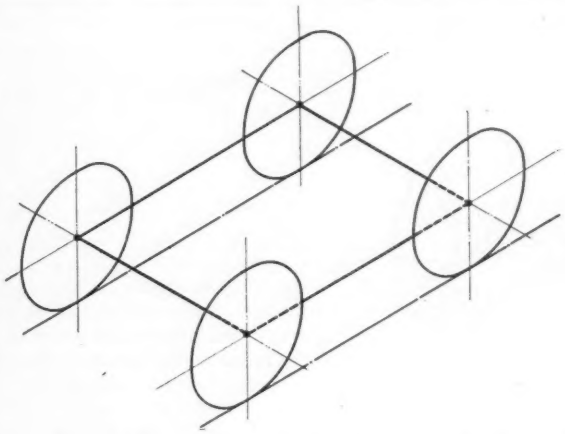


Fig. 1. Two pairs of wheels without equalization

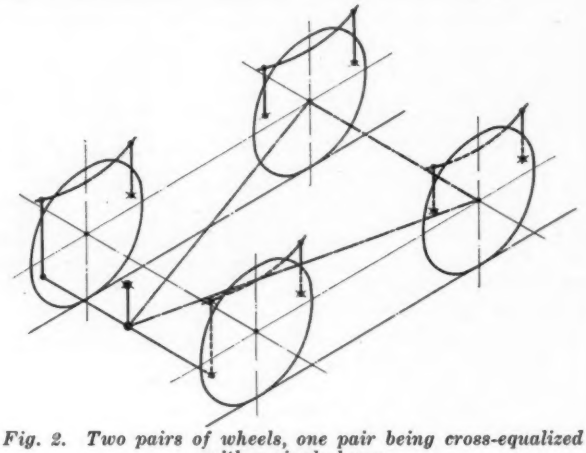


Fig. 2. Two pairs of wheels, one pair being cross-equalized with a single beam

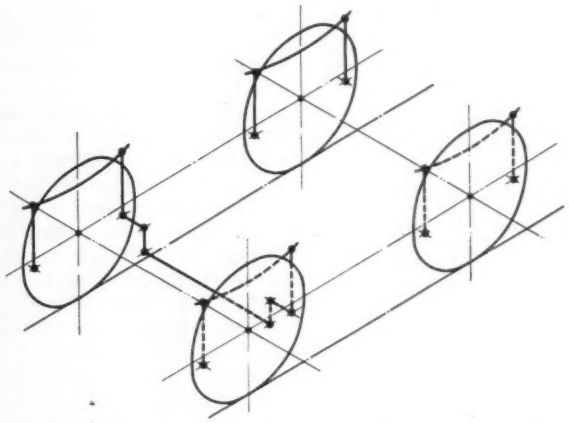


Fig. 3. Two pairs of wheels, one pair being cross-equalized with bell cranks and a tension rod

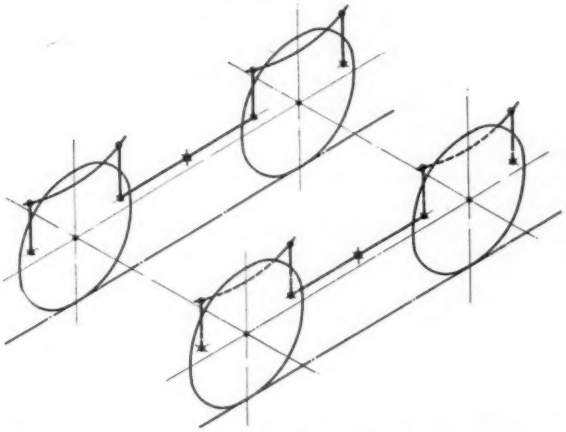


Fig. 4. Two pairs of wheels independently equalized on each side

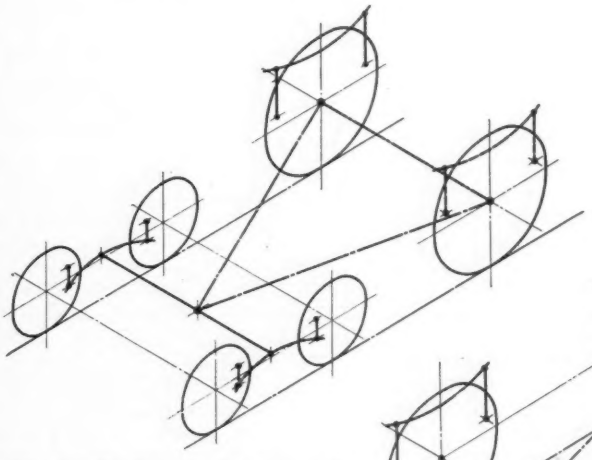


Fig. 5. Single pair of drivers and four-wheeled front truck, as used in locomotive of 1834

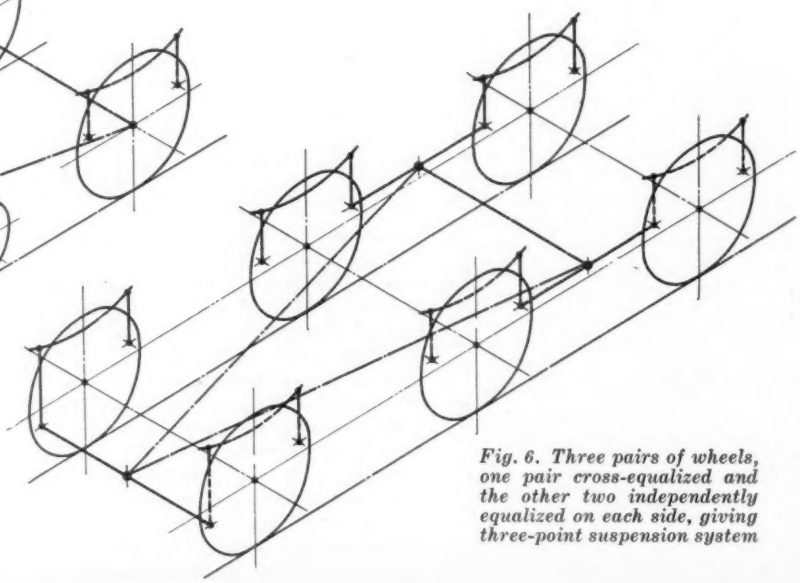
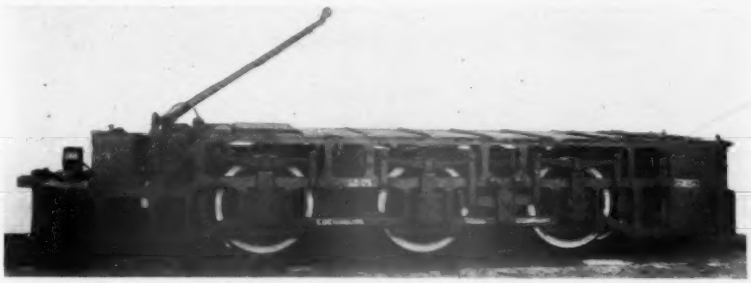


Fig. 6. Three pairs of wheels, one pair cross-equalized and the other two independently equalized on each side, giving three-point suspension system

2½ tons over that of Old Ironsides. Other builders adopted the single pair of drivers and the swiveling bogie, although it is doubtful if the effect of the three-point suspension, as such, was recognized. More wheels for a better weight distribution and a swiveling guiding medium were considered the requisite. Be this as it may, the first really successful American locomotives had accomplished the natural triangular support. It early became necessary to increase hauling capacity, and this could only be accomplished by increasing the adhesive weight. An engine with two pairs of drivers was the next logical step, and Henry R. Campbell, of Philadelphia, was the first to execute such a design, producing the ancestor of the American type, with four drivers coupled and a swiveling bogie truck. But four independently suspended drivers departed again from the natural triangular supporting base and trouble accrued. The Campbell engine was put in operation in 1837, and its defects pointed the way for another Philadelphia firm, Messrs. Eastwick and Harrison, to originate the system of connecting the individual wheel suspensions by a system of equalizing beams. Thus came into existence a principle of locomotive design that distinguished American-built locomotives from those of Europe and made them more flexible and adaptable to track and line variations, solving the problem of weight distribution by equalization.



Six-wheel electric locomotive with one pair of wheels cross-equalized and the other two pairs equalized together on each side, giving the equivalent of a three-point suspension

As locomotive capacity increased and the number of coupled driving wheels were added to, the system was found adaptable to any wheel arrangement, and today no main-line locomotive would be considered if equalization and consequent three-point suspension was not a part of the design.

Equalization is accomplished by fitting each driving wheel journaled into a vertical pedestal formed in the frame and allowing a certain limited vertical motion within this pedestal, restricted by its boundaries and by the spring which bears directly or indirectly on the top of each journal box. Each spring suspension is connected to its adjacent one by a beam pivoted in the frames and linked at its extremities to the extremities of the springs. This system is not, however, continuous. One series on each side is arranged to centralize such support at a median point forming a central fulcrum located approximately on the line of each rail. At the front or back of the locomotive the spring and beam connections are crossed over from one side to the other in such manner as to provide another median point forming a fulcrum on the center line between the rails. The resultant system of support is triangular and forms the desired three-point suspension.

By distributing the shock occurring at any individual point of support over the entire suspension system, an easy riding and flexible machine is obtained, which has a minimum of destructive influence on the rails and likewise on its own component parts.

The four-wheeled tender, as used with many small steam locomotives, illustrates a simple plan of equalization which has been frequently applied to electric mine and industrial locomotives. In the earlier four-wheeled tenders, a system of cross-equalization was used, which had a suitable bearing, or fulcrum, attached to each side of the tender frame and supporting a modified form of bell-crank. One arm of this bell-crank was attached to the end of the tender spring, and the other arm, by means of a suitable tension rod, was attached to the bell crank on the opposite side of the frame. This arrangement has several points bearing on pins, which are subject to considerable wear, necessitating the replacement of pins and rebushing of holes in the bearings, bell cranks and tension rod.

In later four-wheeled tenders an improved design of cross-equalization was introduced. A transverse beam rests upon, or is coupled to, the corresponding springs on opposite sides of the tender, and is fulcrumed on a bearing located on the center line of the tender frame. This system is simpler and lighter than the other and has fewer points bearing on pins, so that maintenance costs are considerably reduced. Both the systems of equalization described above have been applied to four-wheeled electric locomotives of the mine type, and equalization as a principle of locomotive design has adapted the American-built locomotive to all kinds of service in all parts of the world, and has also found much favor with European builders. The accompanying series of diagrams show conventionally the usual arrangements adopted with various wheel plans.

The plan as being used on Baldwin-Westinghouse mine locomotives is shown in Figure 2. Another plan which has been used on locomotives for this class of service is represented in Figure 4. Here an equalizer connects the spring on each side, so that, when passing over rough track, the wheel loads on the same side of the locomotive tend to equalize. Such a system, however, with one point of equalization on each side, is unstable and fails to hold the frame parallel to the rail line. This difficulty can be overcome by using two fulcrums on each equalizer, but if these are placed sufficiently far apart to insure stability in a fore-and-aft direction, the result is practically a four-point suspension system and the benefits of equalization are lost. A locomotive equalized as in Figure 4 tends to ride hard and to derail more easily than one which is carried on a three-point suspension system by cross-equalization.

Although colliery and mining conditions have vastly improved in the last century, it is still a fact that the nature of the industry makes for rough or temporary track not in perfect alignment either vertically or horizontally. It is usually far below the standard set for general traffic railways.

Therefore, it is highly important that locomotives designed for mining service should have a proper system of weight suspension, and to that purpose equalization on the three-point system is always advisable. Such arrangement has insured the longevity of the main-line locomotive and will prove equally satisfactory in the more onerous service of mining railways.

The construction of an $8,000,000 oil shale plant in the eastern Uintah basin, near the Colorado-Utah line, is being considered by the Nevada-Texas-Utah Co. of New York. If constructed, the plant would be completed by 1930, and would handle between 25,000 and 50,000 tons of oil shale daily. The N-T-U company has vast deposits of shale in the basin.

The MECHANIZATION SURVEY

By G. B. SOUTHWARD

Discussion Of Concentrated Mining—Development Required By Hand Loading Compared With Mining Areas For Mechanized Loading In Room-And-Pillar And Long Faces—Advantages Of Concentration Not Yet Determined —New Operating Methods Required

THE mechanization survey which has been conducted by The American Mining Congress has so far attempted to show that mechanical loaders, scrapers, and conveyors are being successfully used to reduce the labor required for the actual coal loading operation at the working face and further to illustrate how these three types of equipment are being applied in the room and pillar system and in modifications of longwall mining. By this time, it is believed that the comparatively large number of successful mechanized mining operations that are now being carried on should convince the most skeptical that the proper and intelligent application of these three types of equipment has resulted in reducing the amount of labor and the cost of loading coal into mine cars as compared with hand methods.

However, loading the coal is simply one phase of mining and it has become apparent that mechanization has necessitated changes from hand mining practices in cutting, blasting, haulage, etc., and it is being more and more forcibly realized that these other operations must be coordinated and systematized to an extent that was not necessary or even possible, in hand mining. We are further discovering that this coordination and systematization will provide the opportunity for increasing the efficiency and reducing the cost of these related operations, and we will undoubtedly find that mechanized loading as it becomes more perfected will not only provide the opportunity but will actually compel a corresponding increase over the present efficiency throughout the entire workings of a mine from the face to the tipple. At the present time, while these possibilities are being recognized the best way of bringing about the changes has not yet been determined and the object of the second phase of our mechanization survey is to show what progress has been made along the lines of coordinating and systematizing the mechanized loading with the related mining operations.

Mechanized loading has already been developed to the point where it has shown that a much higher concentration of workings, a faster rate of mining and a more uniform rate of production can be had than is possible in hand loading, and since many of the changes in the other operations result either directly or indirectly from the concentrated workings, it is the purpose of this article to discuss what this concentration amounts to and how it is made. The later reports, which will be published during the coming months, will deal with actual mining operations, while the following present discussion is, to a certain extent, theoretical in that it deals with several types of mining plans rather than with certain specific cases, but since these plans are based on actual performances it is believed that what they show and the conclusions which follow are fair and correct within reasonable limits.

Three examples of different mining methods have been selected for comparison, and sketches of single panels are submitted as follows:

Figure 1, room-and-pillar with hand loading; *Figure 2*, room-and-pillar with mechanized loading; *Figure 3*, long face with mechanized loading. In these figures none of the plans attempt to go into detail, and it must be understood that their purpose is to illustrate some general principles rather than to compare or indicate specific records and performances, and it must be further understood that they are not submitted with the idea of recommending any of the systems shown.

For the purpose of comparison, each of these panels is assumed to produce the same daily tonnage. However, the tonnage depends directly on the rate of mining or the speed of advancing the entries and rooms, and it is, of course, impossible to specify rates which will have a general or universal application. Furthermore, there is no such thing as an average rate of mining, or, it is better to say, that an average rate of mining which is based on a large number of performances under varying conditions does not have any particular value when applied to a specific case. In making this comparison, therefore, we have to be more or less arbitrary in our assumptions, but it is believed that the figures which are assumed in the following discussion are not biased or prejudiced in favor of mechanized mining. As a mat-

Figure 1—Room and pillar advancing with hand loading in the rooms and entries. Rooms are 25 ft. wide on 50-ft. centers 300 ft. long. Entries are advancing at the rate of one cut each day and the rooms at the rate of one cut every two days

Figure 2—Room and pillar advancing with mechanized loading in rooms and entries. Rooms are 25 ft. wide on 50-ft. centers 300 ft. long. Entries and rooms are all advancing at the rate of one cut each day

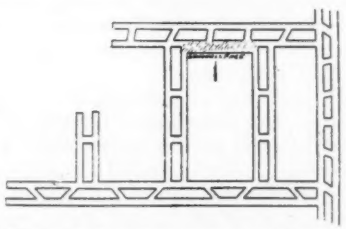


Figure 3—Long face aavancing with mechanized loading in the entries and on the face. Faces 150 ft. long are developed by double entries and mine retreating down to the panel haulway. Entries advance at the rate of two cuts per day and the face mines at the rate of one cut per day

SKETCHES ILLUSTRATING THREE SINGLE PANELS, EACH OPERATED BY A DIFFERENT MINING SYSTEM AND ALL ASSUMED TO HAVE THE SAME DAILY PRODUCTION WHEN DEVELOPED TO THE FULL PANEL CAPACITY AS SHOWN AND OPERATING AT THE MINING RATES SPECIFIED IN EACH FIGURE

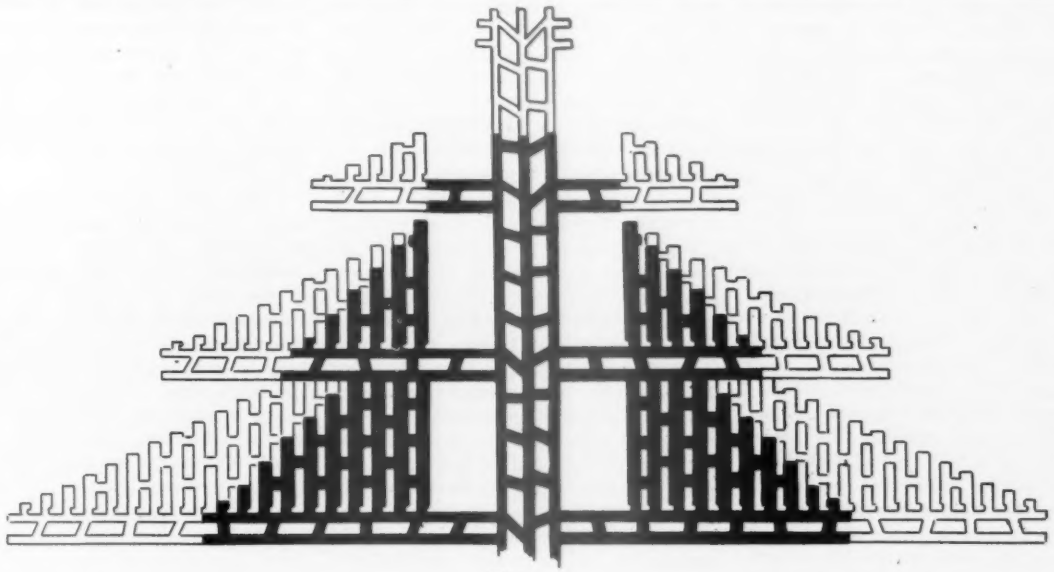


Figure 4

Sketch showing a comparison of the development and mining areas required to produce the same daily tonnages by hand and by mechanized loading operating by the room and pillar system as shown in Figures 1 and 2. The black shaded portions represent the workings with mechanized loading, and the unshaded portions the additional development required for hand mining.

ter of fact, it is highly probable that a mechanized operation will conform more closely to the schedules specified than will the average hand mine.

Figure 1 shows an advancing room-and-pillar panel with hand loading in rooms 25 ft. wide on 50-ft. centers driven 300 ft. long. An entry cut loaded out each day is taken as the average maximum advancement that could be expected in the heading development and in mining the rooms a fair expectancy would be to have a cut loaded out every two days. On this basis, since the entries are advancing at twice the rate of the rooms, there would be 12 rooms working by the time the panel had reached its full development, as shown in the sketch, and this number would continue to be under development as mining in the panel progressed—always assuming that the scheduled rate of driving the places would be constantly maintained. Daily production from this panel would be the tonnage produced from two full entry cuts and half of the 12-room cuts.

Figure 2 shows a room panel advancing with mechanized loading in the rooms and entries. The usual procedure in a mining system of this class is to have

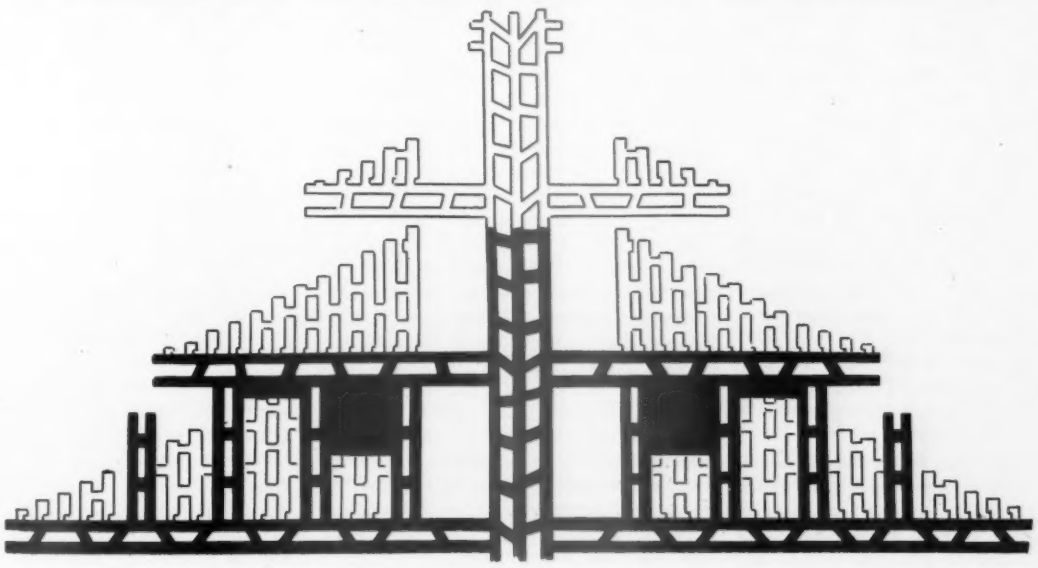


Figure 5

Sketch showing a comparison of the development and mining areas required to produce the same daily tonnages by hand mining in the room and pillar system shown in Figure 1 and by mechanized loading in the long-face method shown in Figure 2. The black shaded portions represent the workings with mechanized loading and the unshaded portions represent the additional development required for hand mining.

under development in a panel only a sufficient number of working places to provide a daily tonnage which will equal the maximum capacity of the machine operation and to schedule the work so that these places will all be loaded out each day. On this basis the entries and rooms will all advance at the same rate, and the panel shown in Figure 2 will reach its full production when six rooms are under development. This number of working places would remain constant as the mining progresses, and the daily production would be the tonnage produced from two entry cuts and six full room cuts, which would amount to the same tonnage as that produced from the hand-mining panel shown in Figure 1. In actual practice the number of places loaded during a shift by a mechanized operation varies under different conditions, but a territory equal to that shown in Figure 2 is now being loaded as a fairly regular performance for a unit operation in a number of mechanized mines.

Figure 3 illustrates a panel worked by a long face advancing with mechanized loading in the entry development and along the face. Because of the many different modifications of longwall, it is rather difficult to prepare a sketch that could be considered as a true representative of this class of mining, and the plan shown in Figure 3 was selected to represent certain principles employed in a number of long face operations rather than as a direct illustration of some particular mining system which is being used. In this plan blocks of solid coal 150 ft. wide by 300 ft. long are developed with double entries and the block itself is recovered by a long face slabbing across the 150-ft. width. In actual long face mining the length of the faces vary from 50 ft. to more than 300 ft. and the dimensions shown in Figure 3 were selected in order to make a direct comparison with the panels in Figures 1 and 2. A face cut 150 ft. long will produce the same tonnage as six full room cuts 25 ft. wide, and in this plan, it is assumed—based on actual operations—that a face 150 ft. long will be loaded out and the timbering and other dead work completed once during each 24-hour period. In order to maintain this production over the life of the panel, the entries are required to advance at the rate of one cut per day.

Summarizing the foregoing, it is obvious that the tonnage produced from a number of working places varies directly as the rate of driving these places, and since it is believed that the rate of advancement assumed for the different loading methods can be substantiated by actual performances, it follows that the mining plans shown in the figures represent an approximate comparison of the working territory required by the three different mining methods. These plans show that there is a concentration in the mechanized loading panels, but the extent and significance of this concentration can be more readily grasped if we carry our comparisons further and extend these systems over several panels to form a section of a mine. This is shown in Figures 4 and 5.

Figure 4 shows a comparison of the development and working territory required in operating a mine by hand loading and mechanized loading, using the plans shown in Figs. 1 and 2, and assuming both mines to be producing the same daily capacity. Both methods are shown to have developed four working panels—two to the right and two to the left of the main entries, and in this figure the black or heavily shaded portions indicate the working places and the territory under development in the four panels with mechanized loading in the rooms and entries. The shaded portions further illustrate the extent to which the working places would have advanced by the time the whole operation had reached its maximum production, starting the development at the main headings and the first panel entry. The lighter or unshaded portions show the development required to produce a similar tonnage with hand loading and also show the extent to which these workings would have reached by the time the mine had developed to its maximum capacity.

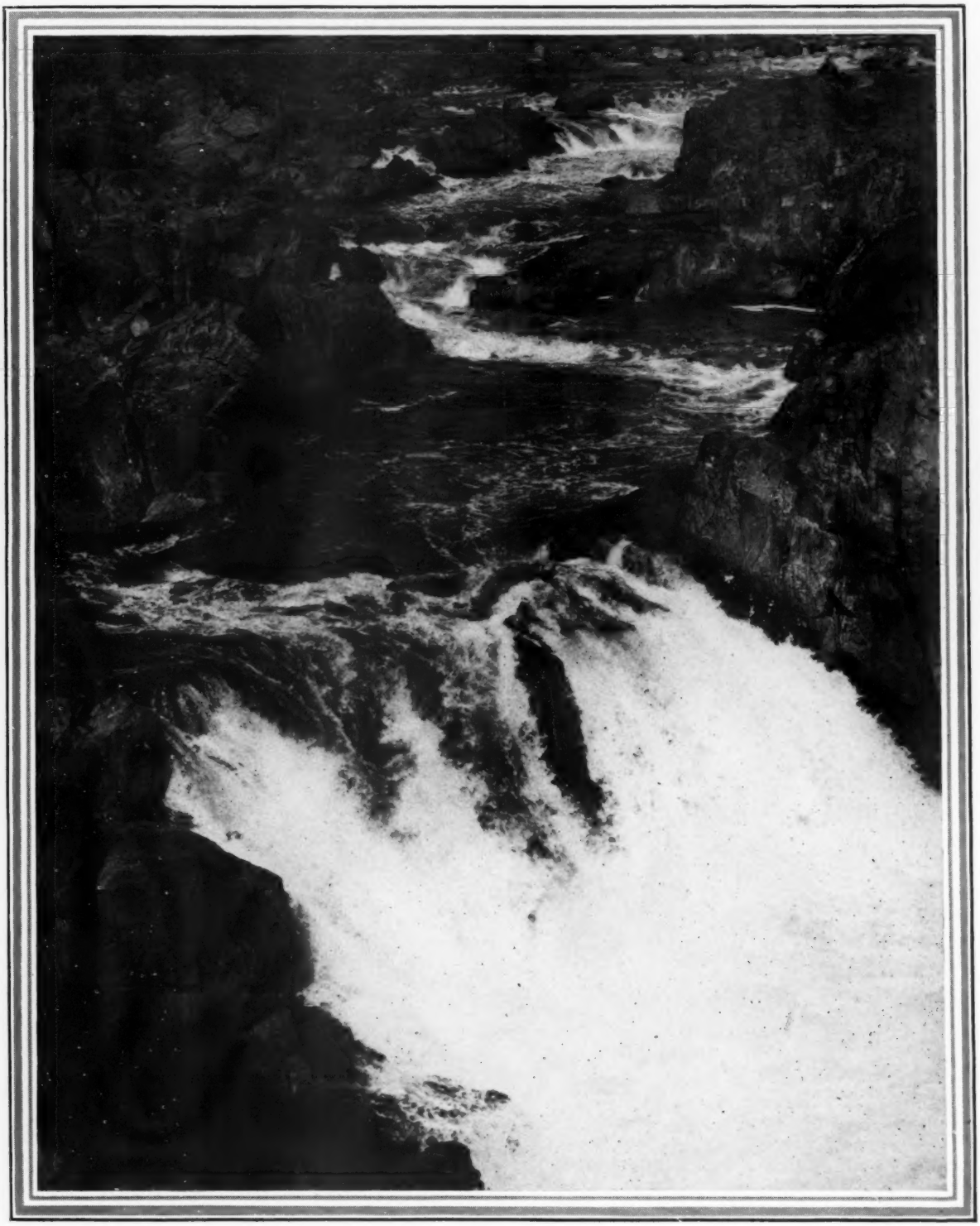
Figure 5 shows a comparison between hand mining in the room and pillar system and mechanized mining on long faces, using the plans shown in Figs. 1 and 3, and assuming that both systems produce the same daily tonnage. The shaded portions indicate the extent to which the working places would have advanced with mechanized loading by the time the operation had reached full production in two panels and the lighter or unshaded portions show the the extent of the development required to produce the same daily tonnage with hand mining. In this comparison it is assumed that the entries are advanced with mechanized loading at the rate of two cuts per day; consequently, these will advance twice as fast as the faces retreat, and the development will soon reach the point where two faces can be worked simultaneously in each panel. Therefore, there would be required only two panels in long-face mining, one to the right and one to the left of the main entries, to produce the same daily tonnage that would be mined from four panels with hand loading in the room and pillar system.

In the three plans shown in Figures 4 and 5, it is not reasonable to expect each panel to operate every day at a 100 percent efficiency, and there should be some extra working territory in order to insure full production from the entire mine. In each plan these extra places would be provided by driving all the main entries and continuing the entry development for the next panels ahead, but this advance work would not necessarily be driven at the same rate as the entries in the working panels.

When these mines have been developed to their full capacity, as shown in Figures 4 and 5, the mechanized operation is concentrated into about half of the territory required for the same production by hand mining. However, as the mining progresses, it is usually found that in hand work it is very difficult, if not impossible, to advance all of the rooms at the same rate (due to the fact that the loading rate of the different miners will not be the same), and the developed territory instead of remaining constant as shown in the sketch will usually become more extended and the workings more scattered. In the mechanized operation, while the daily production and the number of places loaded out will vary slightly from day to day, the rooms are worked in a continuous repeating cycle—loading from the first to the sixth and then back again to the first, so that the number of rooms under development in a panel will remain nearly constant as the mining progresses. In the long-face operation, the work should be always confined to either one or two faces in a panel.

In such items as drainage, ventilation, maintenance of haulways, and air courses, rock dusting and general mine upkeep, the advantages of this concentration seem obvious, but this does not necessarily mean that they will automatically occur. Advantages in the other operations of cutting, drilling, shooting and gathering depend altogether on the degree to which these can be systematized and coordinated with the loading and with each other. It, therefore, seems to be evident that while mechanization provides a concentration, this concentration—in order to be of benefit—requires or may require new operating methods, and the purpose of the next reports in our mechanization survey will be to determine what steps along these lines are in progress or are in view.

The value of the slate sold at the quarries of the United States in 1927 was $10,873,000, according to estimates furnished by producers to the Bureau of Mines. This was 12 percent less than the value reported for 1926. Decrease in demand, especially during the last six months of the year, and lower prices due to keen competition, were general in the slate industry during 1927. Quarries were reported idle, and several firms discontinued business. Consolidation among active firms was also noted.



Great Falls of the Potomac, above Washington ©*Harold Gray*

"The cataract that haunts the rugged steep,
Makes mighty music in its headlong leap."

The SELECTION *and* TRAINING *of* PERSONNEL*

By H. S. Gilbertson †

Most Pressing And Baffling Problem For Operator Is Labor Costs And Performance—Selection And Education Of Miners' Stupendous Task Which Requires Primarily Leadership—Need For Program Of Intensive Local Management, Especially Man Management, Emphasized

THESE sessions of the American Mining Congress are to be devoted largely to questions of mechanization. More power to the loading machines, conveyors and automatic devices! But when the last word on these matters shall have been said in the coal industry, there will remain some hundreds of thousands of men to be dealt with, individually and collectively, and to be reconciled and adjusted as to their technical fitness and their mental attitudes toward the facts of the industry.

This is a meeting of practical men; representatives of invested capital, primarily interested in profitable operation, or, at the very least, solvency. Your most pressing and baffling problem as operating men is labor costs and labor performance generally. In one of the best coal fields, in the year 1921, there was reported an average total mine cost of $2.70, labor cost of $2.05 per ton, of which $1.04 represented wages paid in a tonnage basis, the realization was $2.87, leaving a margin of $0.17. The situation now is infinitely worse.

Ezra Van Horn, chairman of the session on Management and Safety Problems

The solutions to this problem which have been put forward by the industry are two; mechanization and reduction in wage scales. But is there not another solution to which the industry has given insufficient attention?

The leaders of many industries, out of successful experience, would answer "Yes; conserve man power." The point is that what is ultimately desired and needed is a reduction in labor costs, and whatever contributes to that end is presumably all to the good.

In the space of the few minutes allotted to me it will be possible only to outline a certain policy and procedure, in the hope that in some future session of the Congress it will be found desirable to have some of the many phases of the subject presented in detail. Some of the largest of our coal companies have gone rather extensively into one or more phases of the subject under discussion. Their experiences should be made available to the mining industry generally.

Conserving Man Power

"Conserving man power" can be made clear by a simple illustration: Picture a foundry, employing 100 men, poorly selected, uninstructed, badly disciplined and thoroughly out of harmony with their surroundings. Let us suppose that they are producing 35 tons of castings per day. Then reconstruct the situation: Men selected with the greatest care, instructed carefully in the details of their own work, made acquainted with the basic economic facts of their industry and the position therein of their particular employer, supervised by a trained, intelligent foreman who knows both castings and men; all the favorable external conditions possible, good lay-out, quick service from the cupola, modern cranes in good working order, etc. On the same day's wage you produce, let us say, five more tons of castings, better made, with less waste. Unit costs are reduced. You are in position either to enjoy a larger margin of profit or else to put your product on the market at competitive advantage.

To deny that substantial betterments are possible at the mines amounts to saying either that mine workers, for whatever pay they receive, have been giving unstintingly of themselves, their skill, their devotion, their time; that they are wholly adapted in mind and body to the work in which they are engaged; or else that the coal industry is "peculiar" and that better performance and better industrial relations in it are out of the question. Either position seems thoroughly unjustified. We know that some mines are better manned, better organized than some others, and that the difference is reflected in lower costs. We know that some mine organizations are freer than others from the type of worker who is deliberately attempting to make a job for another man, or the type who deliberately slows up transportation, or the one who uses heavy charges of powder and weakens the roof, or the one who smokes in gaseous places, or the one who goes about town spreading false and defamatory information about the company he is working for. Every one of these types is a factor, directly or indirectly, in increased labor costs. The sum total of such workers and their influences, in the industry as a whole, is staggering.

On the other hand, we know of individual mines where the principle of "conserving man power" is strikingly illustrated. One of them is in southern Illinois. Not mere machinery but conserved man power makes it possible for this mine to hoist 12,000 tons in an eight-hour day up a single shaft. By this, I mean that there must have been organization, which meant nothing less than a pervading singleness of purpose, built upon individual ability and desire to do a fine piece of productive work. The essence of the situation is perhaps to be found in the words of a foremost industrial leader, Mr. Owen D. Young, of the General Electric Co.:

"We are learning that productivity of labor is not measured alone by the hours of work nor even by the test of fatigue on a particular job. What we need to deal with are not the limits to which men go without physical exhaustion but the limits within which they may work with zest and spirit and pride of accomplishment."

H. S. Gilbertson

There is no place for magic in the achievement of superior personal service. What is needed more than anything else is first a policy, then some assurance that the policy will be carried out in every last detail of operation.

To begin with, the policy itself must be conceived in the utmost sincerity, bearing in mind that many of the miners harbor a misconception as to what the operators and mine managers really stand for in the realm of human relations. This situation can not be changed by any amount of professions of interest in the workers' welfare or any number of substitutes designed to "make the workers happy and contented." It seems to me that we can get the right slant on this whole matter if we will think not of men as being necessary to operate the machinery of the mines, but of the machinery as an adjunct to your necessary man power. This may appear to offer a rather subtle distinction, but I believe it will serve to focus attention where it belongs. A lively and more constructive interest in the man-power factor on the part of mine owners and managers would be the beginning of better things. Set about to enlist the whole man who comes to work in the morning.

Along with sincerity must go extreme patience. The coal industry has a far longer road to travel than some of the younger industries because so much needs to be undone, so many traditions have to be lived down, before corrective work can be put on a sound footing. You will often be required to wait months or possibly years before just the right setting and the right moment arrives for taking some very necessary action; and you will, in the meantime, have been obliged to lay some careful plans.

So much for the background.

* Presented to Fifth Annual Convention. Practical Operating Men, Cincinnati, Ohio, May 7, 1928.

† Director of Personnel, Lehigh Coal & Navigation Co.

RECONSTRUCTION—THE RANK AND FILE

Turning to direct personnel administration, perhaps its most important function is selection of men. Most operating men probably have their own ideas concerning the relative values of different sources of labor supply. It is not a present purpose to discuss their various conclusions, but rather to register an emphatic protest against any sweeping formulas or generalization and against the old methods of wholesale selection, by carload or shipload lots, which has undoubtedly imposed upon the industry thousands of technical and temperamental misfits, who have caused serious trouble at various points. It would not be possible nor would it be humane to eliminate them from the industry all at once. And yet, there are many changes going on in the personnel of the industry, many vacancies are occurring. It is inevitable that there should be many opportunities to correct old mistakes. The dominant thought in any new program of selection should be the fitness and adaptability of the individual.

Individuals differ widely not only in native ability but in temperament, background and motives. It is possible, however, to classify men as to the kind of appeal which reaches them, causes them to accept a place on the pay roll and to live and to act in accordance with the policies of their employers. For instance, a certain well-known industrialist has a policy of paying wages considerably above the market, but, in return, is said to insist upon an exceedingly rigorous discipline. At the same time he offers nothing in the way of incentives toward a permanent connection with, or a stake in, the establishment itself, such as might be obtained through home ownership, pensions, or stock ownership. Incidentally, his labor turnover is said to be very large. This policy is apparently a successful one within a limited scope. But it does not follow that it could be practiced generally. There are a certain proportion of all men to whom high wages is supremely important, for a time at least. The policy which has been described picks them out of the crowd and puts them on the pay roll. But in that crowd are probably a far greater number to whom a job means something more than high wages; it may mean, for example, a certain freedom that has heretofore gone with the miner's job; it may mean, also, a certain degree of permanency and security in that job. And so, the selection of men implies that you find the particular policies and incentives that draw the kind of men you want. What I shall have to say will relate to a type of men whose number is very large; recognizing, of course, that there are other types or groups who, by reason of their personal history, temperaments and desires, require quite a different sort of treatment.

Many ancient traditions must now be scrapped, for the industry is about to extend, what it has already partially adopted, a new technique of mining and a new discipline. The more or less independent miner who has learned the business from his father by a sort of folklore method, who comes and goes to work pretty much as he pleases and produces what he thinks is a good day's work, must re-educate himself or be re-educated to the mining system in which machine methods predominate, where men work in teams against production schedules, where new methods of development and new applications of explosives are being resorted to, and where higher standards of recovery are being insisted upon. It is the industrial revolution, begun in the latter part of the eighteenth century, which has finally about arrived in the coal industry. No more significant evidence of this development could be cited than the subject matter of these meetings of the American Mining Congress.

In this situation we cannot, with safety, think of the individual worker simply as one who exchanges physical labor for a stipulated wage. If there is any human fact that stands out in all the bitter history of labor relations in the coal industry, especially in the last 25 years, it is the complete and tragic misunderstanding of some of the basic economic facts of modern industrial life.

In our own company we have found it most desirable to acquaint both supervisors and ordinary workmen, in so far as our channels of communication permit, with the specific results which follow from certain policies and attitudes of their own in times past. Thus, I believe that figures concerning the recent declines in the sale of anthracite, especially in New England, and the facts concerning the introduction of oil burners, have been correctly attributed by the workers to high labor costs and recurring interruptions of supply. Short working time in the past year has tended to confirm the predictions contained in the economic teachings of earlier months.

LEADERSHIP

But the selection and education of hundreds of thousands of miners is a stupendous task, especially if individualistic methods are to be employed. Somehow, the task must be organized and delegated. The process must begin at strategic points in the organization.

The answer, in a word, is leadership. Doubtless, the general run of miners, like workingmen of other industries, are not overly gifted with foresight, initiative or insight. But most of them are aware of their limitations and look around for better men to supplement them. Informally, and perhaps unconsciously, they elect a leader, or possibly several of them. It may be a local politician, a fellow worker, a priest or minister, or it may be the foreman.

But the foreman does not always exercise the share of leadership that is rightfully his. In the mine itself there should be no question as to who is the leader, but sometimes there is, even here. When this is the case it is most unfortunate not only from the immediate discipline standpoint but because, if the foreman is not the miners' leader—that is, the man whom they voluntarily look up to—in mining matters, it is doubtful if he can lead in other concerns which are of vital importance to the industry. For, to the miner, the foreman is the company. This is especially true in the coal industry, because the miner and the foreman are neighbors, fellow church members, perhaps, and have other personal contacts outside the mines. It is through the foreman that the industry must transmit its messages of industrial good will, understanding of industrial problems, and so on.

To insure the presence in the industry of such leadership as has been suggested, the matter must not be left to chance. The raw human material must be searched for and must be purposefully trained. Other industries, where the need is not nearly so great, are coming to this conclusion, and many of them have already achieved notable results.

If the foreman has often failed to exercise his full degree of leadership or has directed it to ends which were personal or inconsistent with the best interests of his organization, the fault has been primarily that of the system which has made him, or failed to make him. His superiors have failed for one reason or another, but usually from neglect, to enlist the entire man. For instance, it is of extreme importance to furnish to the practical operating man the detailed knowledge, such as itemized costs, which he needs in order to analyze his problems effectively. Fortunately, the more progressive companies are seeing the value of such a procedure, but it appears to be far from universally followed. To treat an operating man as a hired "hand" working solely for wages, instead of as one of the most determining factors in the industry, is to forego the benefits of a resource of extreme value.

By reason, partly, of the rather doubtful leadership within the operating organization itself, there has grown up, within the industry, a second and often conflicting system of leaderships and loyalties. The second system has grown up principally out of the competitive character of the industry, to be sure, but also to fill the very real need for an organized understanding of the personal factor. Its leadership has learned with increasing effectiveness to touch the springs of human action.

INTENSIVE MANAGEMENT

Now, it is quite possible to shape the leadership of this industry. Other industries are doing this very thing, to a rapidly increasing extent. What is needed is not more instruction in mining methods, but in all the elements of costs, production, safety and, more particularly, the handling of men. There are men in the coal industry who have an instinctive feeling for human values, just as there are men in the newspaper game who have a "nose for news." But, for the most part, they just happen. We must search out more men who have such native capacities and develop them. Mine foremen are eager for such an opportunity to enlarge themselves and their jobs.

The improvement in industrial relations and in the general toning up of the mine organizations which should come through the medium of trained mine leadership, is not only good business in the narrow local sense, but it is one answer to the insistent public demand for better management in the industry generally. May it be humbly and respectfully suggested that some mine owners and managers have possibly attached somewhat too much importance to some of the more obvious differential advantages which attach to particular mines or fields. Some mines enjoy a favorable differential in the matter of freight rates, others in the quality of coal with reference to a particular market. In a highly competitive situation such as now prevails in the industry, it would be insanity not to take advantage of as many of these differentials as possible, and to create new ones, if possible. But the public, in these times, expects the units of the coal industry and every other industry to create another differential—a differential arising out of intensive (*Continued on page* 513)

GENERAL UNDERGROUND SUPERVISION*

By H. A. TREADWELL †

Mine Manager Of Today Must Be Of Same Caliber As Successful Factory Superintendent—He Is Operating Head Of Large Organization And Must Delegate Routine Duties To Subordinates—Daily Reports Of Each Operation And Section Essential—A Method That Has Proved Successful

IN THIS day of a highly competitive market the aim in general has been toward mass production, especially in the automobile industry. In coal mining where the competitive market is ruining the industry, it is only natural that this industry should turn to mass production; so in the last few years we have seen the big mine of yesterday become the smaller mine of today. Fifteen years ago a mine producing 4,000 tons was considered a big mine. Today that has given place to one producing around 15,000 tons.

As the mines have changed in capacity so have they changed in methods of supervision, and it has been this change in underground supervision that has made it possible for the enormous production of today's modern mines.

H. A. Treadwell

The single man managed mine went out of date when we began to aim at big daily tonnages. In small mines of from 100 to 300 employes it is very simple for the mine manager to know personally each man employed; know the condition of his working place and all about this place. It is not difficult for him to acquaint himself with the delays in haulage; the broken down cutting machines, and the delays that run up cost and retard production. This idea of personal contact and the handling of a few men is still carried out in the supervision of large mines.

It would be impossible for a mine manager of today to know all of the 1,200 men working under his supervision as they did when they had 200 or 300. It is impossible for him to travel the entire mine every day or so, as was once customary. The mine manager of today must be of the same caliber as the successful factory superintendent. He must have the daily reports of each operation and each section in front of him at all times. He must have a bogey sheet of unit cost and section production, and must know at all times what to expect from any one section of the mine; and how to gain tonnage in other sections when an accident reduces the tonnage in some one part of the mine.

He is the operating head of a large organization and must delegate routine duties to subordinates having ability to handle them. He has a number of assistants who report directly to him; the machine boss, motor and wire boss, two assistant mine managers, safety man, and haulage boss. Each of the two assistant mine managers has approximately one-half of the mine to look after and exercise the authority of the mine manager in his section. The assistant mine manager's territory is divided into sections employing from 75 to 100 men. These sections are looked after by face bosses. The face boss is the old-time, small-mine superintendent in his own section, and is in complete control of this territory. Everything that is done here comes directly under his jurisdiction. These sections are simply small mines complete within themselves, complete in organization and production. Each is expected to produce a certain number of cars of coal at a prescribed cost. It is in charge of a face boss, who is the mine manager for his section. He has from 75 to 100 men working for him and he is responsible for everything, including the safety of the men and property. He is responsible for the cost of production; the amount of recovery and the amount of development work necessary to keep up his tonnage. It is his duty to know of all accidents and the causes, and to devise a practical method for prevention. He is a busy man, but his territory is small. He has but few men and can see all of their working places two or three times a day. He can and MUST give intensive supervision to get the required results. The effectiveness of this system depends entirely on the ability of the face boss to manage his section.

The machine boss, of course, is in charge of the repair work on all cutting machines. It is his duty to see that machines are in readiness to cut coal. He is supposed to furnish extra machine men whenever a face boss asks for them. All machine runners must be approved of by him as to their ability to operate a machine and to take care of it. It is the duty of the machine boss to see that the machine is in condition to cut coal and that the runner knows how to cut it, but it is the duty of the face boss to see that the coal is cut. If the machine boss has any difficulties that need settling he takes them to the mine manager.

The motor boss is more of a chief electrician than anything else. He has direct charge of the repair work on the motors and the advancing of feeder cable and the bonding of track. He is supposed to look after all electrical work underground. One of his most important duties is to determine the limiting economical load for gathering and haulage locomotives. This limit must be as high as possible, but in many mines motors are abused through over-load. How often have you found a motorman stuck on a hill and when asked the cause of his difficulty he has replied that he didn't know, that he had pulled the hill with the same number of loads. As usual, upon investigation you have found that he has always had more or less trouble with big trips. It is the duty of the motor boss to determine the limiting load of motors so that they will get the most coal without damaging the motor or making the maintenance cost excessive. After the limiting load has been determined it should be rigidly enforced.

One of the big changes in underground supervision is the use of the telephone in directing haulage. In large mines haulage is necessarily long and it is practically impossible to do without a good telephone system and a dispatcher, who is the haulage boss. By the use of a dispatcher sheet on which is marked the time of arrival, the number of loads and from what parting, the departure from the bottom, the number of empties and to which parting they are going, it is very simple to keep track of the haulage with the parting trappers telephoning the arrival and departure of trips. The assistant haulage boss travels the entire mine to give assistance to the face bosses whenever they need it in gathering coal.

One of the most important assistants to the mine manager is the man in charge of safety. This man must be competent and his whole duty must be safety alone, and nothing whatever to do with production.

In mines where high daily tonnage is sought it is very important that the loaders be given plenty of time to load their cars to capacity. There is no way in which the output of a mine can be increased more easily with a reduction in cost than by the increased average weight on the pit car. One way of accomplishing this is to set a minimum weight for the average car and have the company weighman make a sheet showing the number of light cars coming from each section. As soon as the shift is over this report is posted in the bosses' wash house so that each face boss can see how the cars from his section averaged for that day.

To work any machine effectively and efficiently, whether in a mine or in a manufacturing plant, it is necessary to keep a record of all repairs, both as to labor and material. This record is kept by the use of a time card by the repairman. He puts down the time spent on each machine with a list of material used. This card is turned in at night to the machine boss who signs it and sends it on to the stock room where the

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† Engineer, Chicago, Wilmington & Franklin Coal Co.

material used is priced; then it is forwarded to the time keeper who figures the time, posts all the information on individual machine cards. As the mine is divided into sections one repairman has the same machines to look after. Each week he is required to inspect and O. K. one machine and note it on his time card. By this method the management knows the condition of each machine in the mine at all times. At the end of each pay period the tonnage is placed on the machine card in the office and the cost figured. This method gives an individual record of each machine in the mine and is really of great assistance in the picking of good machine men as well as good repairmen.

The repair work on the motors is kept in the same manner with an additional record of every motor that goes to the shop during the working shift, the length of time it is there, and the cause of the difficulty. This record with the time card system shows at once whether the repair work is being done properly or only half done.

Each motorman has a book of blank report sheets and at the end of the day he signs a report on which is noted the entries where the motors worked, how many loads were pulled, shows any delays; time lost waiting for empties, waiting for loads, break downs, lack of electric power, cars off the track, and where derailment occurred. These reports are turned in to the face boss, who signs them and they are given to the haulage dispatcher who turns them into the office. These reports are totaled in the office for each motor and posted on individual motor cars. At the end of each month the card is totaled and it gives a complete record of that motor.

At the end of each month a cost sheet is made showing the itemized cost of each section, also number of cars pulled, the number of docks, the average weight of the cars, the number of loaders, the number of day men, the tonnage produced per man, and the number of trivial and serious accidents for each section. With these reports at hand it is very easy to follow the progress of each section from day to day and get the best results from the entire operating force. These reports may seem to take much time but if you look closely you will see that the record will not require much more than five minutes of any one bosses' time during the day. The work is all done in the office by a clerical man. These reports which are always available to the organization makes it possible for any member to keep familiar with all of the individual equipment both in operation and maintenance, as well as the operation of each individual section in the mine.

When the mine manager makes an inspection of a section he has a definite knowledge of what has been going on in that section. He knows what to expect and what to look for. He does not have to waste time in looking around to see what is going on. Routine inspection trips are left to his assistants and he must visit the places that are in trouble.

The results obtained by the method are that the mine manager and superintendent know the exact operation of each section. From the individual cost sheet they know all the good points as well as the weak points of each boss. It gives them the chance to strengthen the "weak sisters" by means of information.

Unless you keep an individual record of all machine operations, individual boss records, and in fact, all separate detailed costs and production, your only means of information is by inspection and much guess work.

H. S. GILBERTSON, *Lehigh Coal & Navigation Co.*, discussed Mr. Treadwell's paper, saying:

"I am very much interested in what Mr. Treadwell had to say about the position of the mine manager of a large mine and thoroughly agree with him, as a matter of fact, but here is the situation we find in some of the anthracite mines: The foreman, as we call him there, corresponding to the mine manager, is a man who has had practical training. He has been a practical miner, grown up through the ranks, and a good many of those old foremen, particularly, do not seem to have the knack of delegating functions. I should like to ask Mr. Treadwell what sort of training, if any, they supply to the man who is the head of a mine of say, 1,200 men, so that he will be able to keep his hands off the details and really delegate them to the foremen or face-bosses, or whatever name they have.

"We have tried out the foreman training in our organization with a great deal of satisfaction. I can say that we found this, that the man who has had the old-time training is not only receptive but he is eager to get the kind of training which he needs to make a bigger man of himself.

"As I suggested in the paper, we believe that a mine foreman should be something more than a mere mining man. Of course, it is a pretty big thing to be a mining man, but it is a still bigger thing to be a mining man plus a man who can handle men and also appreciate the ramifications of the mining industry.

"We believe that foremen should be the men to whom the miners can look as their leaders. They should represent the company's problems in the right way.

"We have our problems and you have yours (to Mr. Treadwell). There are the questions of realization and cost and safety. As I said in the paper, also, there is a certain amount of what you might term economic information, leadership, that can be exercised by the foreman. I believe, however, as Mr. Treadwell said, that the traditional foreman, the man who was brought up in the old school, is going to have a very difficult time to measure up to what the modern mining organization requires. I dare say that the mines in the future in general are going to be big mines. They will have to be organized along the lines that Mr. Treadwell suggested. It is going to take bigger men to run them than the old-time foremen.

"We have some young men in our organization coming up who grasp these ideas rather better than some of the old men. We hope that the next generation will be still better. The thing to do, it seems to me, is to strengthen the thing from the bottom. We should start with the person whom we call the assistant foreman, the man whom (in Mr. Treadwell's organization) they call the face boss. Those men have to be trained with the idea that some day they will be managers of men and not simply hunters for gas, and things of that sort."

(In reply to MR. GILBERTSON'S inquiries, MR. TREADWELL stated:)

"That is one of the most difficult problems that you will meet in working out of this organization work. What you have experienced in your mine we have experienced in Illinois. We have tried every method that we knew of before we finally came to this method of operation. A man to be a successful mine manager under this method of operation must be of the caliber of an underground superintendent. It is one man among a lot of men whom you can find who will delegate the routine duties of this position to subordinates.

"We have a man now who is an old State Mine Inspector and has been in the mining game for years. He has adapted himself to this method of management, I believe, because of his training as State Mine Inspector. It takes a great deal of perseverance and patience to work out the duties of a mine manager that he should delegate to his subordinates. However, it is the only method that we have been able to find by which a large number of men can be successfully handled."

MECHANICAL VENTILATION AT THE MINAS DE MATA-HAMBRE

(*Continued from page* 493)

some repair work in the north and central parts of the upper levels. As these portions of the upper levels depend on natural ventilation, which is ample for the number of men employed on these repair jobs, and are cut off from the ventilation raises by doors, there is a natural tendency to steal a little air by blocking open a door. While it was a common thing at first, due to a little consideration on the part of the bosses with an explanation as to why the doors could not be left open, this trouble has been practically eliminated.

Unfortunately, due to the short time the fans have been in operation, there are as yet no instruments on hand to measure the humidity and velocity of the air passing through the mine. However, temperatures have been taken in the same places where they were taken before the fans were put into operation. The results show that there has been little or no reduction in temperature. This bears out the theory that "a high velocity, even with comparatively high temperature and high relative humidity, may give the same rate of cooling as that obtained with quite low temperature, low relative humidity, and considerably less air movement."

In general the mechanical ventilating system installed in the Minas de Matahambre has:

(1) Bettered the morale and spirits of those employed underground.

(2) Speeded up the work, especially tramming.

(3) Decreased the rate of decay of timber, especially in the main haulage ways to the shaft, for the fungus and "cotton" has practically disappeared.

ADVANCEMENT *of* ROCK DUSTING PRACTICE *in* PENNSYLVANIA, MARYLAND *and* WEST VIRGINIA*

By CHARLES ENZIAN †

West Virginia Shows An Increase Of Four Hundred Ninety-Three Percent; Pennsylvania Increased Her Percentage One Hundred And Five, While Maryland Showed No Advancement—The Value Of Rock Dusting Demonstrated — Considerable Progress Has Been Made In Lowering Costs.

THE advancement of rock dusting practice in bituminous coal mines outside of the above states is presented to this Convention of the American Mining Congress in two sections. Mr. John E. Jones, safety engineer, Old Ben Coal Corporation, Illinois, has prepared a presentation of the advancement in the coal-mining states west of Pennsylvania, Maryland and West Virginia. The advancement in the States of Pennsylvania, Maryland, and West Virginia is herein presented.

Charles Enzian

It is common knowledge that during the past 20 years coal dust explosion hazards, and preventative measures thereof, have engaged the serious attention of government and coal-mining operating officials in Europe and in this country. During the first 15 years of that period the advancement in the rock dusting practice was indeed very slow; this, undoubtedly, was due partly to a natural characteristic of practical operating men to cautiously accept or adopt new departures or innovations, especially in view of the uncertain market conditions that pervaded the bituminous coal industry during the past decade. It was hardly to be expected that under such conditions those responsible for the successful operation of the property under their charge should glean sufficient encouragement to undertake, much less seriously promulgate, matters other than those absolutely essential to the most economical operation of the coal mines.

The writer firmly believes that the apparent lack of interest in the advancement of rock dusting practice was not entirely due to the lack of interest in any important matter that pertains to the safety and welfare of the mine workers in their employ or the preservation of the property intrusted to their care—at least not to the extreme degree that the uninitiated may be led to believe in reading some of the press releases and investigation reports by state and government mining departments. Quite the contrary is true. The far-sighted coal-mining operator is intensely interested and eager to adopt real practical safety measures when they have been proven practicable, and this is exactly what has happened during the past four or five years. Up to that time there were few, if any, state or government officials who had a really practical mechanical method of applying rock dust in coal mines or any practical knowledge as to the operating cost of the practice. However, many were quite enthusiastic in voicing their belief in the efficacy of rock dust in preventing the propagation or localizing coal dust explosions. Those who have kept in close touch with the developments of the subject know that the perfecting of practical mechanical rock dust applicators during the past four years was (*Continued on page* 513)

* Presented to Fifth Annual Convention, Practical Coal Operating Men, Cincinnati, Ohio, May 7, 1928.

† Mining Engineer, Berwind-White Coal Mining Co.

TYPICAL EXAMPLES OF ADVANCEMENT MADE IN THE COST OF DUSTING PRACTICE

Company	Cost of Equipment	Year	Cost Per Ton Coal Mined: Dust	Labor Applying	Total	Barriers: No.	Barriers	Average Cost Total Expense	Remarks
Pa.-1 (L. V.)	$5,000.00	1925 1926 1927	0.0103 0.0049 0.0058	0.0041 0.0022 0.0020	0.0144 0.0071 0.0078	110	90.00 Each	0.0416 1st Yr. 0.0098 (3 Yrs.)	One section dusted to 72 percent incombustible at end of year, 40,000 tons coal hauled over it (normal condition) incombustible was 46 percent. Total mileage dusted—51.
Pa.-2 (H. V.) (2 Mines)	3,185.00	1924 1925 1926 1927 Avg.	0.0030 0.0030 0.0040 0.0030 0.0040	0.0030 0.0010 0.0010 0.0010 0.0010	0.0060 0.0040 0.0050 0.0040 0.0050	65	62.00 Each (0.0018)	0.00896 (4 Yrs.)	Average cost per ton includes cost of equipment, repairs and maintenance and all other items incident to rock dusting. Total mileage—229.5.
Pa.-3 (L. V.) (1 Mine)	900.00							Ranged from 0.012 to 0.008 0.0101 Avg. (3 Yrs.)	Average cost per ton includes cost of equipment, repairs and maintenance and all other items incidental to rock dusting.
Pa.-4 (L. V.) (4 Mines)	5,267.00					37	104.00 Each 0.0026	0.0104 to 0.0151 Avg. 0.0132 (1 Yr.)	Average cost per ton includes cost of equipment, repairs and maintenance and all other items incidental to rock dusting.
Pa.-5 (H. V.)	7 for 10 Mines						None	0.0015 to 0.0025	Average cost per ton includes cost of equipment, repairs and maintenance and all other items incidental to rock dusting.
Pa.-6 (H. V.)	14 for 16 Mines						256	0.006	Average cost per ton includes cost of equipment, repairs and maintenance and all other items incidental to rock dusting.
Pa.-7 (H. V.)	19 for 17 Mines						86	0.0053 (1925) to 0.0050 (1928)	Average cost per ton includes cost of equipment, repairs and maintenance and all other items incidental to rock dusting.
Pa.-8 (a)-L. V.	5 for 7 Mines						122	Not available	
(b)-H. V.	4 for 4 Mines						None	$7.86 per ton rock dust applied	Rock dusting arrested a dust explosion.
(c) H. V.	2 for 2 Mines							Not available 0.0079 per lin. ft.	

ADVANCEMENT *in* ROCK DUSTING PRACTICE

By J. E. Jones †

A Review Showing Developments In United States West Of Pennsylvania And West Virginia—Idea Of Rock Dusting As Positive Safety Measure Has Been Sold To Industry—Improvement In Equipment And Rock Dust Supply

THIS paper is one of two papers prepared upon this subject for this session of The American Mining Congress, the purpose of the two papers being to cover this subject by considering the nation in two sections; that territory east of Ohio and Kentucky considered by Mr. Chas. Enzian of the Berwind-White Coal Mining Co., and that west of Pennsylvania and West Virginia considered in this paper.

It is with considerable gratification that those interested in mine safety view the advancement that is accomplished in this comparatively new safety measure. It has not been so long ago, 1910, that the United States Bureau of Mines experimental mine was developed to give to the mining industry the benefits of conclusions derived from actual work with explosions, the only installation of its kind where mine explosion conditions can be duplicated at will, and the possible prevention of an explosion ascertained.

John E. Jones

Your attention is also called to *Mines and Minerals*, December, 1912, in which an article by Samuel Dean of the Delagua Mine of the Victor American Fuel Co., Colorado, is contained upon the rock dusting of that mine. This article could be copied under recent date and fit well in an illustration of recent rock dusting practice.

Further thought and application of this safety measure lay dormant until 1917 when Old Ben Coal Corporation of Illinois began an intensive use of rock dusting in its several mines. A rather amused tolerance was given by the employes and the mining industry in general, until the experiences proved the effectiveness of this measure, and about 1923 many individuals and companies became interested in its possibilities. It is from this date that advances in rock dusting practice will be considered.

The chief advancement made is that the idea of rock dusting as a positive safety measure has been "sold" to the industry. There is scarcely a dissenting voice against this measure as being one that is fundamentally sound. Recent Bureau of Mines statistics show that about one-fourth the bituminous tonnage of the United States is from mines that are either partially or wholly protected by rock dust. This is exceedingly encouraging when one considers that its installation has been wholly in a period of adverse mining circumstances. It would be difficult to find another safety measure that would in any four years of development, compare in growth with rock dusting.

It must also be considered that benefit has resulted among the three-fourths bituminous production which operations have not rock dusted, in that many of these producers have a more definite knowledge of their explosion hazards; those having these hazards conducting other explosion safeguards accordingly. Some of those not rock dusted have found from mine dust analyses that their mines are sufficiently high in ash content, because of natural conditions, to stop explosion propagation.

An advancement in the territory assigned to this paper is that 15 states in which coal is mined has rock dust installed in some of the mines of each state. The coal fields in these several territories in which rock dusting is being done serve as nuclei for growth and the spreading of this safety measure into the coal mines that need it is more certain because of the advantage of knowledge and experience from near-by neighbors.

There is not a coal field containing explosion hazard in the territory assigned to this paper but that has in it coal mines that are rock dusted. The following is a brief summary taken from Bureau of Mines statistics and answers to questionnaires upon the present rock dust status of these states.

Illinois

In Franklin County, which has a potential production of 105,000 tons of coal per day from the mines operating in 1928, there is rock dusted in whole or in part that number of mines which have a production of 102,500 tons daily; this being approximately 97 percent of the total.

In the other Southern Illinois coal field mines where rock dust is necessary, an estimate of 30 percent of the mines are rock dusted.

An appreciable percentage of the coal tonnage of this state comes from mines that will not need rock dust protection. These mines include stripping operation and long wall and other mines where the ash content from soft shale roof gives the mines a natural rock dusted condition. This is true in some of our other coal mining states.

Indiana, Ohio, and Kentucky

Progress in rock dusting has been rather slow although a few companies have given their mines good rock dust protection. An estimate of 10 percent of the production which requires this protection has been given, wholly or in part, rock dust installation. The mining law relative to this safety measure in Indiana has not yet functioned to be of much value.

Rocky Mountain States

One of these, Utah, has a mining law that requires rock dusting. Strict compliance with this law has not yet been observed, but this safety measure is gradually growing. Nearly all of the mines have been rock dusted in part and a few are well dusted.

In New Mexico and Wyoming most of the tonnage is produced by a few companies, which companies have been rock dusting thoroughly for the past few years.

Rock dusting in Colorado has not been as widely done as the hazards would lead us to expect. However, the mines producing one-seventh the tonnage are protected.

Washington

Several mines in the Roslyn coal field are well rock dusted. Other companies are now contemplating the installation of this safety measure.

Southern States

Most of these coal mining states have adopted rock dusting in a few of their mines, some of the mines being given full protection.

Advancements have been and are now being made in this safety measure that are needed for efficient installation. Among these is the development of good rock dusting machines, it being acknowledged that the better and less costly practice is that of rock dust coating as compared with barrier installations. Another advancement is that of rock dust supply, there being more and therefore better available sources of rock dust for the various mining fields.

An encouraging factor in the further promotion of this safety measure is the attention given to it by mining associations, congresses and institutes and their dissemination of the knowledge in relation to value, cost, application and the further details of interest. From this interchange of ideas and experiences almost the entire industry has learned that the cost of this measure is well under one cent per ton of coal produced, that to be of maximum value the mine must be thoroughly rock dusted and that no matter what the local conditions might be, sufficient fine ash can be applied so as to make the resultant mine dust non-propagating of explosion flame.

Further advancements are noted in the psychology of managements and men relative to their faith in and promotion of this safety idea. The amused tolerance of former years has changed to a sincere desire that rock dust be installed and maintained in their mine;

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* Presented to Fifth Annual Convention, Practical Operating Men, Cincinnati, Ohio, May 7, 1928.

† Safety Engineer, Old Ben Coal Corp.

even so far that in at least one mine the miners rock dust by hand application the roof and ribs after each cut is loaded.

The theory of why a high ash content dust extinguishes flame is now fairly well understood by the rank and file in our industry, the experience in several mines wherein explosions have been localized by having rock dust application have substantiated this theory and the advancement in the installation of this safety measure in spite of adverse economical mining conditions give reason for our optimism that the elimination of the disastrous mine explosion is not in the distant future but is now a possibility of solution, only requiring a continuation of the advancement in this safety measure that would now exist under normal working conditions.

In answer to an inquiry as to what extent their rock dusting is conducted in their working faces, in their rooms, and likewise on their haulage roads and air courses, MR. JONES said:

"We take care of the haulage roads by coating the roof and the ribs by means of rock dust machines. In the rooms the machines are not taken further than the room neck, but the dust is shot into the room as far as it can go and is then carried on by the ventilating current. Where the track is not installed, such as air courses, protection is given by rock dust barriers. The barriers are made from troughs. I understand that there are mines where rock dusting is done to the room faces, and as shown in my paper, where the ribs are dusted as each coal fall is taken out. Such mines are more numerous in the Western States.

"I wish at this time to express my appreciation to the many companies, associations, individuals, and to the Bureau of Mines for their answers to my questionnaire in the preparation of my paper."

ADVANCEMENT OF ROCK DUSTING IN PENNA., MD., AND W. VA.

(*Continued from page* 511)

the one greatest advancement made in the rock dusting practice.

In a paper on this same subject, read before the congress's convention in 1926, the writer presented some potent facts and figures on two typical mines rock dusted to conform with the requirements as standard practice by the Pennsylvania Compensation Rating Bureau. Close contact with developments, and the gradual adoption and expansion of the practice has been maintained since that time, making a more or less continued study of much that has been done, experimentally and in practice, for a period of 15 years. He has observed and experienced, in turn, the complete cycle of change of attitude of the practical operating men, passing through the stages of placid indifference, open opposition, critical skepticism, facetious tolerance, awakened interest, and finally the recognition and adoption of the principle and the practicability of the practice in preventing or limiting coal dust explosion hazards. It is his observation that just as soon as the results of state and government investigators, and the practical mine experiments emerged from the more or less purely theoretical and academic stage and became translatable into the general operating scheme of coal mining, the executives and administrative officials of coal-mining companies became keenly alert to its real value and the practice thus got its greatest impetus. The fact remains that all this happened during the short space of five or six years. In that time practical application methods have been devised and practical specifications for mines and materials usuable for this purpose were formulated by those best qualified to propound them.

The rate of advancement was slow, but, as stated before, this was due principally to the unfortunate fact that the case-hardened business executive of a coal-mining company is by nature cautious. He requires considerable time and proof positive that an invention or innovation is sound in principle and is practical in operation. Unfortunately, this mental and physical process requires time, and quite generally the formative period of really sound and practical inventions is fraught with bitter experiences. To those who have given thought and have studied this subject, and perhaps there may be some not yet quite convinced of the real economical value of rock dusting, let us point out that state and government mining departments and bureaus have made available considerable information bearing on the results of scientific studies abroad and at home, practical explosion experience in minimizing disasters, specifications of procedure and the kind of materials suitable for rock dusting. For convenience to those who are not familiar with the literature available, allow me to present a partial list of the more practical and valuable recent publications:

COAL DUST EXPLOSIONS—How they can be prevented—Simple remedy in practical operation. *John E. Jones, safety engineer, Old Ben Coal Corporation*, 1924.

ROCK DUSTING OF BITUMINOUS COAL MINES—Efficacy, methods and costs. *Edward Steidle, Carnegie Institute of Technology*, 1924.

TENTATIVE SPECIFICATIONS FOR ROCK DUSTING TO PREVENT COAL DUST EXPLOSIONS IN MINES. *Rice, Paul and Sayers—U. S. Bureau of Mines, Reports of Investigations*—Ser. No. 2606, 1924.

REVIEW OF COAL DUST INVESTIGATIONS. *George S. Rice, A. I. M. E.*, 1925.

ROCK DUST MATERIAL FOR COAL MINES. *U. S. Bureau of Mines—Information Circular No.* 6008, 1926.

SOURCES OF DUST IN COAL MINES. *U. S. Bureau of Mines—Reports of Investigations.—Forbes and Emery*, 1927.

ROCK DUSTING IN COAL MINES. *U. S. Bureau of Mines—Information Circular No.* 6030—*Rice, Sayers and Harrington*, 1927.

EFFECTIVE ROCK DUSTING OF COAL MINES. *U. S. Bureau of Mines—Information Circular No.* 6039—*George S. Rice*, 1927.

STATUS OF ROCK DUSTING IN THE UNITED STATES. *U. S. Bureau of Mines—Reports of Investigation*—Ser. No. 2856—*Harrington, Forbes and Forhan*, 1928.

There are also available a number of bulletins and technical papers published by the United States Bureau of Mines on the results of more than 1,000 experimental coal dust explosions by the bureau in its experimental mine at Bruceton, Pa.

The time available for this presentation does not permit going into the minor details of rock dusting advancement made in the area here discussed, but the following composite tabulations are of interest.

WEST VIRGINIA

In 1926 there were 1,201 mines in operation; 15 of these were "using rock dust" in 1925, while 90 were using rock dust in 1927, showing an increase of 493 percent. This indicates that 18,000, or 18 percent of the employes out of a total of approximately 100,000 underground employes, are afforded rock dust protection. The increase of the practice is steadily continuing, and, no doubt, the practice will become quite general, especially in the gaseous mines.

MARYLAND

Ninety-seven mines were in operation in 1926; none were using rock dust in 1925, while one was using rock dust in 1927. This indicates that 162, or 5 percent of the employes out of 3,200 underground employes, are afforded rock dust protection. This statement of Maryland's advancement in rock dusting practice should be qualified to the extent of quotations from a letter from the chief mine engineer, Dr. J. J. Rutledge, in which he states: "Our conditions are peculiar. We have other conditions requiring more of our attention than does rock dusting; please do not think we are unmindful of the virtues of rock dusting."

PENNSYLVANIA

One thousand nine hundred and sixty-three mines were in operation in 1926; 63 were using rock dust in 1925, while 129, or an advancement of 105 percent, were using it in 1927. This indicates that 44,000 employes, or 32 percent of the approximately 136,000 underground employes, were afforded rock dust protection.

SELECTION AND TRAINING OF PERSONNEL

(*Continued from page* 508)

management, which includes, among other things, the most effective and intelligent employment of the most expensive factor in production costs.

For somewhere along the line such intensive management must exist if there is to be an improvement in the coal situation. A lowering of freight rates to any market would throw a burden of management back upon the railroads. A lowering of wages, to the mine workers' way of thinking, would be simply creating a problem of domestic management for them, unless they are convinced of the necessity of such an adjustment. They have not always been shown the evidence that all has been done which can be done before the companies proceed to "take it out of the miners." Without such a conviction on the part of the rank and file, it is easy to understand the difficulty of the leaders' position. Possibly the real mistake in all the wage negotiations has lain in too much reliance upon collective bargaining, for which a proper foundation had not been established in individual mine relations.

The coal question, in the last analysis, will not be settled by congressional committees nor by legislation, nor yet by interstate or regional conferences of operators and union leaders, essential though such meetings may be in a competitive situation. When one or more, or all, of these agencies shall have made their respective contributions, there will remain the need for a program of intensive local management—and especially man management—in each individual mine.

SAFETY EQUIPMENT DESIGNED *to* PREVENT ACCIDENTS*

By D. HARRINGTON †

Permissible Equipment Necessary To Offset Additional Hazard Of Increased Use Of Machinery—Use Of Cutting Machines Lessens Necessity For Heavy Blasting And Prevents Roof Fall—Special Attention To Safety Equipment Not Now Being Utilized—Enumeration Of Necessary Safety Devices

IN a recent article in a mining magazine discussing present day practice in a certain mining region a statement was made that "due to increase in efficiency, introduction of labor-saving machinery, and greater use of electric power it is estimated that three men are employed where five were formerly necessary." While there is no definite method to check the exactness of this statement or its applicability to the coal mining industry as a whole, there is absolutely no question that, due largely to extension of use of machinery, output per man employed in our mines has been greatly increased and it is definitely believed by at least some mining men that this increased use of machinery, especially of electricity, has greatly increased the hazard of mining to those who are actively engaged in it. It is undoubtedly due to the increase in mine dangers brought about by the more widespread use of machinery that notwithstanding the much greater attention given safety in mines than was given 10, 15, 20 or more years ago, yet our accident rate per 1,000 men employed remains practically as high as it was in the fairly distant past. It appears that as use of machinery is expanded in our mining operations the best efforts of our most progressive mining people are required to devise and hold in effect additional safeguards to retain or maintain our accident rate at or even slightly above (or worse than) the past rate and our inability to accomplish results in accident reduction is due very largely to additional hazards from machinery plus our seeming inability to make anything like progress in prevention of accidents from falls of roof, coal, etc. Had it not been for the numerous safeguards instituted in connection with the manufacture and use of underground machinery the hazard from extension of use of mining machinery would have been decidedly worse than it is.

Dan Harrington

Manufacturers of electrical equipment and machinery for mine use have expended hundreds of thousands of dollars, together with an enormous amount of energy, time, and study upon this problem of making mine equipment reasonably safe. The Bureau of Mines subjects this machinery and equipment to decidedly rigid tests such that if used with even reasonable care and kept in reasonable repair there is little or no danger of its failing to come up to expectation in so far as the safety features involved in the permissible tests are concerned. While there is an ever increasing number and percentage of ignitions, fires, and explosions in mines due to nonpermissible electrical machinery or equipment, decidedly few cases are on record where permissible equipment has caused ignitions, fires, or explosions and there isn't available a single well authenticated instance of failure of permissible equipment where it was used with even a fair degree of care. Notwithstanding this concerted effort of many of the manufacturers and of the Bureau of Mines there continues in use in our mines nonpermissible equipment and machinery with attendant inexcusable loss of life and of property. In 1927 out of a list of 54 ignitions, fires, and explosions with 229 fatalities in our mines, 21 were of electrical origin, the deaths in these disasters of electrical origin being 151; in every instance the ignition was from nonpermissible equipment. In addition there was 13 ignitions, fires, or explosions with 31 deaths from use of open lights although there are available permissible electric lamps which if used would eliminate such disasters; there were also 13 disasters from blasting with dynamite or black blasting powder with attendant 37 deaths although there are available permissible explosives which if even fairly carefully used would eliminate or at least largely reduce the number and seriousness of accidents from blasting.

Hence while there are available permissible electrical locomotives, mining machines, loading machines, pumps, etc., which have not been guilty of igniting gas or dust or of causing fires, there is continued in use by over 75 percent of our mines, nonpermissible electrical equipment which from ignitions, fires, and explosions in our mines caused at least 151 deaths in 1927, 123 in 1926 and nearly 700 out of a total of 1820 such disaster fatalities from January 1, 1921 to

* Presented to Fifth Annual Convention, Practical Operating Men, Cincinnati, Ohio, May 7, 1928.

† Chief Engineer, Safety Division, U. S. Bureau of Mines.

Method of applying water to cutter bar to duce coal dust raised into air during operation of undercutting in coal seam with sumping operation

Undercutting in coal seam with mining machine without use of water. Dense dust which was raised is not shown clearly in the picture

January 1, 1928. It is said that some of our large coal producing states have absolutely no permissible electrical equipment in use underground. Again we continue to have deaths from explosions and fires due to open lights, there being at least 31 in 1927, 202 in 1926, and 930 from the period January 1, 1921, to January 1, 1928. While there are decidedly safe efficient electrical lamps available nevertheless only about one-third of our coal miners and practically none of our metal miners use these safe efficient lamps. Notwithstanding the fact that there are available reasonably safe permissible explosives but about 1/3 of our coal is shot by permissible explosives; blasting with nonpermissible explosives resulted in disasters in 1927 with 37 deaths, in 1926 with 42 deaths and in the period from January 1, 1921, to January 1, 1928, there were at least 195 killed due to fires or explosions from nonpermissible explosives. While use of permissible equipment and explosives will not eliminate accidents from mines, there is absolutely no question that with universal use of permissible equipment and explosives the fire and explosion hazard would be very greatly reduced provided there continued in use, common sense precautionary measures and methods in ventilation, haulage, etc.

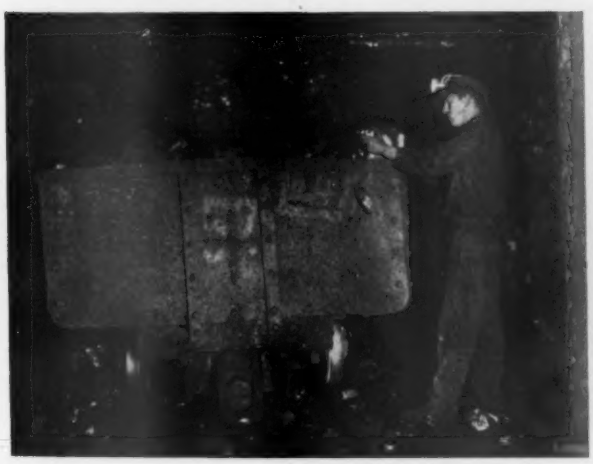
In an Information Circular, entitled "List of Permissible Mining Equipment," issued in January, 1928, the U. S. Bureau of Mines calls attention to equipment which has been very carefully designed by manufacturers and equally carefully tested by the Bureau of Mines in order to assure that such machinery or equipment can be used safely in mines. The list includes the following permissible electrical equipment: three types of air compressors; ten types of underground loading machines and conveyors; three coal drills; 17 mining machines; 1 hoist; seven pumps; one concrete mixer; three rock-dusting machines; three junction boxes; eight electric cap lamps; three hand and trip lamps; one flash lamp; one methane indicating detector; one mine telephone; eight single-shot blasting units; 14 gathering locomotives; one main line haulage locomotive; five power trucks; and one tandem locomotive. Since the January list was published there has been given a permissible approval to an electric safety lamp for detecting methane. The Bureau has also

Permissible Single Shot Blasting Unit

given permissible approval to four types of oyxgen breathing apparatus; five types of gas masks; eight flame safety lamps; one flame-type methane detector; and to a long list of permissible explosives.

The most baffling as well as the most prolific cause of fatalities as well as of nonfatal accidents in our mines is that of falls of roof or wall material. In general, mechanical equipment has not had very much effect towards either increase or decrease of this type of accidents. However, there is no doubt that use of top-cutting machines to leave coal roof where the immediate roof material is "tender" has had a very helpful effect in reduction of accidents from roof falls in some mines. There is also no question that use of machines to undercut, overcut or shear, has allowed bringing down coal with much less violent blasting than where solid shooting is done, and this has also aided materially in reduction of accidents from falls. Mechanical equipment at or near faces usually makes much noise and here is one of the most hazardous features of the new or concentrated systems of mining where various types of cutting machines, loaders, conveyors, scrapers, blowers, drills, etc., all noise makers, are in use; the noise prevents the worker from hearing the preliminary or premonitory small warnings given by splitting props or falling splinters of rock or coal before the main mass of material falls. The newer systems of mechanized concentrated mining usually require the completion of the cycle of operations each shift or several times per shift, this to include cutting, shooting, and loading together with such timbering as may be necessary; this entails the removal of roof support over a considerable area while the shift is in the mine, and there is much more caving of roof while many men are nearby than with the older systems. Unless there is care taken to control the roof adequately by cribs or cogs rather than by placing reliance upon comparatively weak posts or props, there are likely to be numerous multiple accidents from roof falls in the concentrated mechanized mining work. The pulling of pillars in the older type of mining, as well as most of the concentrated systems which use loaders, conveyors, scrapers, etc., demands removal of props to reduce and control roof action; many deaths continue to occur through use of the ax and hammer to remove props yet there are available comparatively safe prop pullers of mechanical design.

There are numerous hazards as well as many safeguards introduced into mines in up-to-date haulage equipment. Swiftly moving cages, skips, locomotives, cars, trips, etc., cause many violent deaths annually in our mines, and there is absolutely no doubt that our later day modern haulage has had a somewhat similar effect on underground hazards as the automobile and other up-to-date media of locomotion and haulage have had on our surface streets and roads. The trolley locomotive as well as the trolley-reel type are efficient but they are decidedly dangerous, not only because of possible gas or dust ignitions but also because of contact electrocutions; under no circumstances should they be used in return air in any mines which give off methane. There is no question that these locomotives should be eliminated from mines, and their places taken preferably by permissible storage-battery locomotives not only for gathering but also for main-line haulage. In gen-

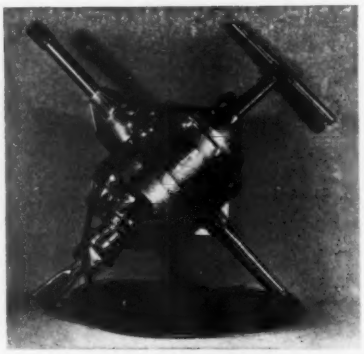


Solid no-gate steel car with roller bearing wheels. Miner is wearing a permissible cap lamp

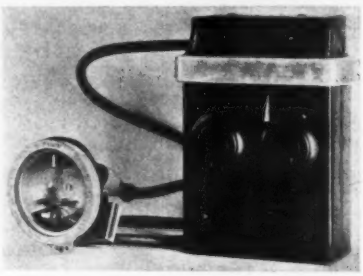
Up-to-date lamp house for permissible electric cap and magnetically locked flame safety lamps

eral the handling of men on cages, skips, man trips, etc., is done with comparatively small loss of life, yet there is a very great hazard in the handling of comparatively large numbers of men in man trips on inclines where the pitch is between 30 and 70 degrees; there are however fairly adequate safety devices in the form of safety dogs to catch runaway cages or skips where the pitch is above 70 degrees and there are fairly adequate safety catches for trips on inclines less than 30 degrees. Many cages which handle men are not equipped with adequate doors, and many which have doors do not use them; similarly, many shaft or incline landings or shaft collars do not have tight doors or gates to prevent men or material from falling into shafts, although safe gates are easily placed and operated. While there are adequate fairly positive devices for hoists to prevent over winding, many hoists which handle man-carrying cages and trips are not equipped with these safety devices. Many shaft mines have but one shaft equipped with hoisting appliances to raise the men in the mine in case of emergency in which one hoist is out of commission; this is a serious mistake and whenever the shaft is tributary to workings deeper than 300 feet, there should be two or more shafts with hoisting equipment sufficient to raise the shift in less than an hour. Shaft signalling systems should be of more than one kind, in every shaft and one of these should by all means be of such nature that signals can be given from the moving cage as well as from each shaft station; this is done in but a comparatively few instances, but it should be universal. Some mines have man-handling cages controllable from the cage in a manner similar to elevators in office buildings and it is decidedly advisable that this type of installation should become more prevalent. By no means do all man-handling cages have adequate safety bonnets to protect against falling objects nor have all cages adequate safe chairs at landings, yet there are available safe bonnets and safe landing chairs.

A tabulation of 172 mine disasters of which there is a fairly definite record as having occurred between 1910 and 1921 in the United States indicates that of these 172 disasters at least 63 or 36 percent were due to blasting; a tabulation upon a similar basis for 1926 gave but three disasters from explosives out of a total of 17, or 18 percent, while in 1927 on the same basis there were two disasters out of 9 or 22 percent; hence there is good reason to believe that progress is being made as to reduction of accidents from blasting. There is no doubt that much of this progress is due to the use of permissible explosives in displacing black blasting powder and dynamite in regions where there was maximum blasting hazard. Nevertheless, there were at least 37 fatalities in our coal mines in 1927 and at least 42 in 1926, due to explosions and fires from nonpermissible explosives, and it is probable that practically all of these approximately 40 lives annually lost through use of nonpermissible explosives would be saved if all of our coal mines instead of only about one-third used permissible explosives only. There is no valid reason why there should be used for any purpose in any coal mine, any explosive other than permissible explosive and the permissible explosive should be shot electrically. Explosions continue to be precipitated or individuals to be killed by premature blasts, hangfires, misfires, etc., from use of fuse or squibs in blasting while there are readily available safe efficient methods of blasting electrically. Where electric blasting is used, it is frequently done without regard to real safety; ends of electric detonator lead wires are not kept twisted or short-circuited though it is well known that this is a very definite safeguard against stray currents or other premature detonation, and some explosives detonator manufacturers now supply short-circuited lead wires. Batteries with open leads, or bare power wires are used for securing electric current for blasting, though there are available safe, efficient shot-firing units. There is also available a safe, efficient method for putting off all mine blasting holes electrically from the surface when all persons, including shot firers, are out of the mine, yet very few mining companies use this very excellent system. There is now also a method of bringing down or "blasting" coal by use of carbon dioxide; whether this method is safe, efficient, or economical has not yet been thoroughly established though its advocates claim all three attributes for it. There continue from time to time disasters or near disasters due to accidental discharge of explosives while hauling them in cars attached to electric locomotives; this is not at all necessary as there are readily available fully insulated cars in which to transport explosives and also efficient insulated couplings to be used as an additional safeguard.

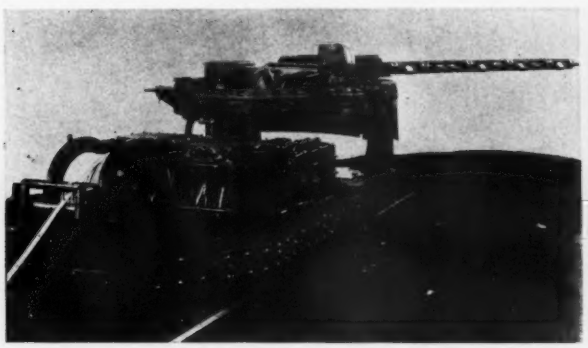


Permissible Electric Drill

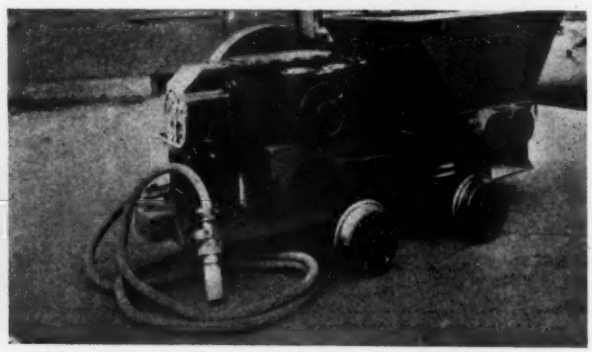


Permissible Electric Cap Lamp

In addition to the explosion hazard from electricity there is a decided hazard from accidents fatal or nonfatal from contact with electrical conductors or equipment there being annually at least 100 persons killed in our mines in this way. The exposed trolley wire is one of the worst offenders and while it is rarely done the trolley wire or any other bare current carrying wire (except possibly very low-voltage signal wires) should be well protected by nonconducting guards at all points where such bare conductors are less than 6½ feet above the track or floor. It will be a long step in the direction of safety in mines both coal and metal when the trolley or trolley-reel or crab locomotives are displaced by the permissible storage battery locomotive not only for gathering but for main haulage. In fact, our mines can not be made even reasonably safe from electrical ignitions or contact accidents until the wireless mine is at hand; presumably, this will mean the driving of locomotives, pumps, mining machines, loading machines, etc., by permissible storage batteries and it is to be hoped that this time will not be long delayed. The open type of "nip" on mining machine trailing cable and on cable of cable-reel locomotives, etc., is decidedly dangerous and its use should be prohibited by law, and it should be supplanted by nonarcing connectors or junction boxes.



Permissible Electric Coal Cutting Machine



Permissible Type Rock Dusting Machine

The practice of "*nipping*" mining machine to the face of development entries or to or past room necks or partially driven crosscuts off entries has caused numerous gas ignitions, and this type of ignition is of increasing frequency. The use of bare uninsulated power wires is dangerous from various points of view and all underground power lines should be of powerfully insulated cables well protected by effective grounding. This sounds drastic, but unless there is a decided reform in the use (rather the misuse) of electricity in mines there is certain to be drastic legislation as to electricity in mines; a conservative experienced coal-mining engineer recently said that 90 percent of "mysterious" fires in mines are from electricity.

In ventilation of mines, considerable progress has been made in equipment; efficient high-speed fans, electrically driven, steel encased, with steel approach are almost wholly displacing the old cumbersome timber-cased, steam-driven fans; and few if any of the later type fans are now placed without ample provision for prompt reversing of direction of air currents, if desired. Curiously enough, this reversing of air features is seldom tried out and seldom if ever are underground doors so placed and so equipped as to allow of reversing of air direction if the reversing were desired. There are available safe effective mine doors yet probably much more than half of the doors found in mines are neither safe nor effective. There are available effective informative pressure-recording gauges for mine fans yet few fans are equipped with them and little or no use is made of these valuable devices even where they are in place. There are available permissible magnetically locked flame safety lamps yet there continue to be used in large numbers unsafe single-gauze lamps or key-locked double gauze lamps. There are available gas testing boxes with which flame safety lamps can be tested before taking them into the mine and thus *know* that the lamps are safe. Again, but few of these boxes are used. There are available comparatively inexpensive apparatus which allow of comparatively quick and accurate determination of gaseous content of mine air yet very few mining companies use these devices or equipment. It is known that widespread explosions as propagated by coal dust can be absolutely prevented by rock-dusting and while there are available comparatively effective and inexpensive rock-dusting machines and fairly efficient rock-dusting can be done for not to exceed one cent per ton on coal output, fewer than 10 percent of our coal mines use rock dust and probably not 1 percent rock-dust effectively. One of the most effective means of reducing dust in coal mines is use of water on the cutter bars of mining machines while cutting, yet probably not 5 percent of the coal cutting is done with machines equipped with watering devices. It has been found that one of the most unhealthful of underground occupations is that of machine drilling of blasting holes without use of water at the drill bit; while wet drilling has made much progress in mines in the United States during the past 15 years there continues to be much decidedly dangerous, unhealthful dry machine drilling and this should not be allowed either in coal or in metal mines.

While there is much safety equipment used and much available for use where unsafe material is in use there are numerous needs as to safety equipment which should be but is not available and especially is there urgent need right now for:

Permissible electric cap lamp—Two inches

1. A safe, efficient device for testing mine air, to displace flame safety lamps as it is inconsistent to continually introduce a flame into explosive gas, where common sense demands that flame and explosive gas should by all means be held apart. Electric gas-testing devices are available, but while they indicate explosive gas they give no indication as to oxygen content, and the latter is a decidedly necessary requirement.

2. An efficient not too expensive permissible storage battery to displace all types of equipment requiring the electric wiring of mines.

3. An efficient yet not too costly method of fireproofing mine timber.

4. A safe dependable method or device for the detection of unsafe or unstable roof conditions.

5. A more dependable roof support than timber and, as yet, nothing fully satisfactory has materialized.

6. A safe efficient substitute for all kinds of explosives in both coal and metal mines, or for some method of mining to allow of elimination of explosives from mines.

Permissible Methane Indicator

7. A device or method for the safe detection and handling of hangfires or misfires in blasting in mines.

8. A safe effective method of flood lighting in connection with concentration of men where mechanical loaders, conveyors, scrapers, etc., are in use. Incandescent lighting is by no means safe at or near faces likely to be gassy or dusty or both.

9. A pit car which is wholly enclosed top as well as sides and bottom; and car wheels which do not break as easily as present day wheels break under the hard usage given them in mines.

10. A reasonably inexpensive system of belt haulage which will eliminate pit cars, locomotives, etc.

11. A trailing cable which does not arc in being attached or detached from the power lines, or which will not become short-circuited by falls or by being run over by wheels.

12. A device on cutting machines to insure removal of coal cuttings (bug dust) from the cut or kerf.

13. A method of propelling mining machines from place to place without the use of the dangerous practice of "nipping."

14. A device which will give automatic warning when methane content of mine air runs above two percent.

15. An efficient method of safeguarding man trips on slopes up to 70° from runaway in case of breakage of couplings, coupling pin or haulage rope.

16. An inexpensive, fireproof, efficient mine door.

There are scores, even hundreds, of safety devices and pieces of equipment in use in mines of the United States, and the main difficulty in connection with them is the problem of securing the adoption by the entire industry of the safety equipment being used by portions of the industry. It is particularly desirable at this time with intensive mechanization of mines well under way, yet still in its infancy, that far more attention be given the matter of selection of safe equipment. It is decidedly fallacious to believe or infer that intensive mining by application of machinery will in itself automatically care for safety of the mine or of its workers; unless much more attention is given the selection of safe equipment and also safe methods and safe practice and maintenance in connection with that equipment in our concentrated mechanization work, the safety of our mine and of our miners will be decreased rather than increased by the newer systems. On the other hand, there is absolutely no good reason why mine safety may not be increased rather than lessened with the concentrated mechanized systems if a reasonable amount of attention and good judgment as to safety is used in the newer type of underground work.

***JOHN T. RYAN**, Mine Safety Appliances Company,* discussing this paper said:

"Mr. Harrington has covered his subject in his usual effective and complete style and he doesn't leave very much for us to discuss, except to emphasize the importance of some of his recommendations.

"He has certainly set a mark for us to shoot at, both in the way of developing safety equipment and the installation of same in our mines. One might think that he has established ideal standards. Possibly he has, but we must have an objective to strive for, and it does not necessarily (*Continued on page* 532)

VENTILATION *of* GASEOUS MINES*

By RICHARD D. MAIZE †

Fourteen Points Presented Specifying Fan Of Two Separate Driving Units, With Ample Capacity Operated As An Exhaust —Only Specified "Permissible" Equipment Should Be Used—Trolley Wire Electric Locomotives Kept On Intake Airways— Elimination Of Trap Doors—Velocity Of Air Current On Main Intake Airways And At Faces Should Be Kept Low

IN PRESENTING this paper it is not the intention of the writer to go into a scientific or technical discussion of means and methods for mine ventilation, but rather to present some practical suggestions and recommendations based on personal observation.

In presenting methods for ventilating a gaseous mine the problem would be much easier if the mine to be ventilated could be submitted for study and consideration. But since this is not the case we will have to assume certain conditions and submit for your consideration ways and means of taking care of the various problems met with in the ventilation of a gaseous mine.

Richard D. Maize

When the engineer is asked to prepare plans and specifications to ventilate a mine, he should know, first, the maximum number of men to be employed in any one period of 24 hours. This information is necessary to help him to decide on the minimum amount of air required by law. Second, the thickness of the coal seam. This information is necessary so that he will provide a sufficient number of air courses and ample area for the passage of the required amount of air with the minimum velocity and the minimum amount of power consumption. Third, the approximate amount of methane which may be encountered, and, if possible, where the most methane will be given off, from the coal or overlying strata. Fourth, it would also be necessary for him to know the kind of power to be used for mining and hauling of the coal and pumping the water.

For the purpose of this paper we are going to assume the hardest kind of problem, the ventilation of a gaseous mine evolving methane from the coal and overlying strata, and using electrical power for mining, hauling and pumping.

With the foregoing assumption it is reasonable to assume the installation of a fan of ample capacity to produce the required amount of air, with sufficient reserve power to be used in case of emergency.

Two separate driving units, one on each side of the fan, are so arranged that in case of emergency one could be stopped and the other connected and started with the minimum delay. In addition to the extra driving units the fan should be equipped with an auxiliary gasoline engine of sufficient size to operate the fan for several hours at the same speed it was being operated by the main driving unit. This is especially recommended in gaseous shaft mines where power is purchased from public-service corporations or is generated at central power plants and transmitted long distances, which makes the power supply subject to interruptions caused by storms.

The fan should be primarily an exhaust, reversible fan, equipped with explosion doors to relieve the pressure and reduce as far as possible, to a minimum, damage to the fan in case of an explosion.

The electric equipment of the mine should be of explosion or gas-proof type and bear the permissible plate of U. S. Bureau of Mines, indicating its permissibility for use in gaseous mines. I understand permissible equipment is now available for all kinds of mining machinery except electric locomotives operated from the trolley wire.

It is a foregone conclusion that the mine should be developed and ventilated for an exhaust fan and all electric locomotives operated from the trolley wire be kept on the intake air ways. The natural deductions are that the mine must be ventilated on the exhaust system. With this method the main haulage roads and traveling ways would be on the intake air, making an easy means for entering the mine in case of mine fire or explosion.

The main return air courses should be of ample area and sufficient in number to reduce the velocity of the air to a maximum of 850 ft. per minute to prevent as much as possible the carrying of coal dust in the air current. Assuming the amount of air required to be a maximum of 300,000 cu. ft. per minute at the ventilator, it would require six main return air courses carrying approximately 50,000 cu. ft. of air per minute and a 60-ft. area; you would have an average velocity of about 840 ft. per minute in each of the main return air ways. Of course, if large air ways could be provided, it would be possible to carry more than 50,000 cu. ft. of air in each air way and still maintain a low velocity.

The question has often been asked at mine foremen and mine inspectors' examinations, "Which should be the larger, the main intakes or main returns"? The answer has been the main returns, and some textbooks on mining also make the same statement. Without giving any reason for their statements other than "due to the amount of gases given off in the mines increasing the volume of air in the main returns over and above that in the intakes" requires the main returns to be the larger.

The writer has never agreed with that answer, and he always contended that the air ways in which the main haulage is being done should be the larger whether they are intakes or returns. Therefore, in the case under discussion the intakes should be larger than the returns, so as to reduce the velocity of the air current and to provide extra area for the obstruction and congestion caused by rapid moving trips on the main intake haulage roads.

For the proper ventilation of a gaseous mine the intake airways should be sufficient in number and large enough in area to reduce to a minimum the coal dust thrown into suspension from the loaded cars traveling out against the ingoing air. Assuming that the area of the intake airways is of sufficient size to reduce the velocity of the intake air to 400 ft. per minute and the velocity of the loaded trip was only 600 ft. per minute, then the combined velocity acting on the dust is equal to 1,000 ft. per minute, and this is not considering the extra velocity due to the obstruction of the airways caused by the moving trips. The empty trip going into the mine would be traveling with the air, and of course could travel at a greater speed than the outgoing trips.

The ideal arrangement is to plan the mine so that it can be ventilated without the use of trap doors, but this is an ideal seldom, if ever, found in practice. The writer has seen a number of plans and specifications where a mine was to be developed and ventilated without trap doors, but after a while the management found they had some sections of the mine which were too small to ventilate as a separate split, and would combine two splits by the use of trap doors; and in other cases they found they had the air current divided into so many splits that the volume of air in the various splits of the mine was too small to dilute, carry off and render harmless the smoke and noxious gases. And in some cases even if the gas was properly diluted and sections clear of smoke, the quantity of air in the split was less than the minimum amount required by the laws of that state.

The mine should be planned and developed in such a manner so as to reduce the number of trap doors to a minimum, and where it is necessary to use trap doors they should be arranged to form an air lock which will prevent the air from short-circuiting when one of the trap doors is open. Where necessary to use trap doors they should be substantially built, and the frame of door built in with brick laid in cement. All stoppings and overcasts in a gaseous mine *must* be built of incombustible material; stoppings in crosscuts in rooms may be built of canvas or boards.

With the total volume of 250,000 cu. ft. of air at the ventilator and allowing

* Presented to Fifth Annual Convention, Practical Operating Officials, Cincinnati, Ohio, May 7, 1928.

† Mine Inspector, Uniontown, Pa.
Presented for Mr. Maize by Mr. Glasgow.

25 per cent loss between the ventilator and the workings, there would be available 187,000 cu. ft. of air for distribution in the various splits. Assuming 10 splits of air, there is available 18,700 cu. ft. of air for each split. The minimum amount of air required in each split would depend on two things; first, the amount of methane given off from the coal and overlying strata; second, the number of men on the split.

The minimum amount of air in each split should be 12,000 cu. ft. per minute, which would provide ventilation to meet the requirements of the mining law of most of the states, permitting the employment of 60 men on a split. This much air should be provided even if there was not sufficient methane given off to contaminate that much air. The maximum number of men on any split should not exceed 70, and with 10 splits the number of men possible would be about 600, because you could not always keep the splits up to the maximum number of 70 men, and it would be almost impossible to plan and develop a mine without the use of trap doors and have 70 men on each split at all times, unless longwall system of mining was adopted. Some splits may be finishing and others just developing, which would cut down the number of splits available in which you could employ the maximum number of men.

Where necessary the ventilation should be conducted to the face of rooms and headings by line brattice, and the volume so conducted should only be sufficient to remove the smoke and keep the working places clear of methane. No attempt should be made to conduct the full volume of air on the split into the workings unless the working place is making so much methane that the total volume is necessary to keep the place clear. A high velocity at the working places should be avoided due to coal dust, incident to the mining and loading of the coal, being carried in the air current.

The ventilation should be directed into the rooms by use of checks or lightly constructed doors on the heading. One door or check located on the heading between No. 1 and No. 2 rooms and the other on the heading between the last room and the room next to the last one. Crosscuts between No. 1 and No. 2 rooms should be closed with boards or canvas excepting the last one, from which a line brattice should be stretched to the face. The same thing should be done in crosscuts between the last room and the one next to the last one. Line brattice should also be used in keeping the headings free of accumulations of methane. After the rooms and headings have been driven to their boundary and the extraction of pillars has been started the ventilation should be conducted into the rooms as stated above. The line brattice, however, is not necessary, but the air should be coursed along the faces and directed on to the pillar falls to keep them free from explosive gas. It is well before starting to retreat with any panel or section to drive places through on to the return from other panels and use these as "drains or bleeders" to drain the methane off the falls direct into the return. In some sections it has been found advantageous and sometimes very necessary to drill bore holes from the surface into the pillar falls to drain off the methane.

The return air from each split should be tested once each week with a Burrell Methane Detector to find what percentage of methane is in the return from that split. If the methane content exceeds one-half of 1 percent, the ventilation on that split should be increased to keep the methane content at the predetermined amount of one-half of 1 percent. If it requires more than 25,000 cu. ft. of air per minute on the split to keep the methane content to one-half of 1 percent in the return, the work on that section should be slowed down until the methane drains off. Samples of the return of each split should be taken once a month and sent to the chemist to be analyzed for the purpose of keeping a check on the person who is taking the readings with the Burrell Methane Detector.

Where mines have been planned and developed to conduct the ventilation without the use of trap doors, they have never planned for a large number of men on one split. The minimum number of men on the split would be about 10, and the maximum number about 40, which will indicate to you the large number of splits required for a mine employing 600 men. The writer is not in favor of trap doors in any mine where they can be eliminated, but he appreciates the fact that in developing a mine it would be necessary to combine the air in two or three splits with trap doors until the sections become sufficiently developed that they can be put into separate splits.

An ideal system of ventilating a gaseous mine would be to assume a shaft mine opened in the center of the property and developed by driving nine main entries, east and west, or north and south, into the main body of the coal, using the five center entries on each side of the shaft for intakes, using two of the five for haulage roads, two for traveling ways, and, of course, the extra heading for ventilation and any other use desired. The four other entries would be main returns, two on each side of the five inlets. At regular intervals flat headings should be turned right and left off the mains. These should be driven in series of fours, the two center entries for main inlets, haulage roads and traveling ways, and the two side entries for returns. In each section where the flat headings turn off the main entries right and left, it would require four overcasts on the right side to carry the fresh air into the flat headings and the return air from the flats and from other parts of the mine inby from this point over the fresh air.

The same arrangement would be required where flat headings turn off to the left of the mains. Off the flat headings, room or butt headings could be turned right and left. It would require two overcasts on the right and left air courses to pass the return air over the fresh air which went into the room headings. The room headings would be driven in series of threes; turning rooms off the two outside ones taking the fresh air up the two-room entries, meeting at the top of the headings, and returning down the center entry. With this method of development doors are eliminated entirely from the main entries, flat entries and room headings; the hauling at all times being done on the intake airways.

From a study of the facts so far stated, the writer arrives at the following conclusions for the ventilation of the gaseous mine:

(1) Fan of ample capacity must be provided.

(2) The fan should have two separate driving units.

(3) An auxiliary gasoline engine should be installed, to be used in case the power fails.

(4) Fan should operate as an exhaust.

(5) Ample airways should be provided, providing more inlets than returns.

(6) Permissible electric equipment should be used.

(7) All electric locomotives operated from a trolley wire must be kept on intake airways.

(8) Velocity of air current on main intake airways and at working faces should be kept as low as possible.

(9) Trap doors to be eliminated as far as possible. Where trap doors are necessary, air locks to be provided so the air will not be short-circuited.

(10) The maximum number of men permitted on any split depends on the state laws and the amount of methane evolved.

(11) The minimum number of men on a split depends on the available working places.

(12) The maximum amount of air on a split depends on the amount of methane given off.

(13) The ventilation should be conducted into the working places by check doors and line brattice.

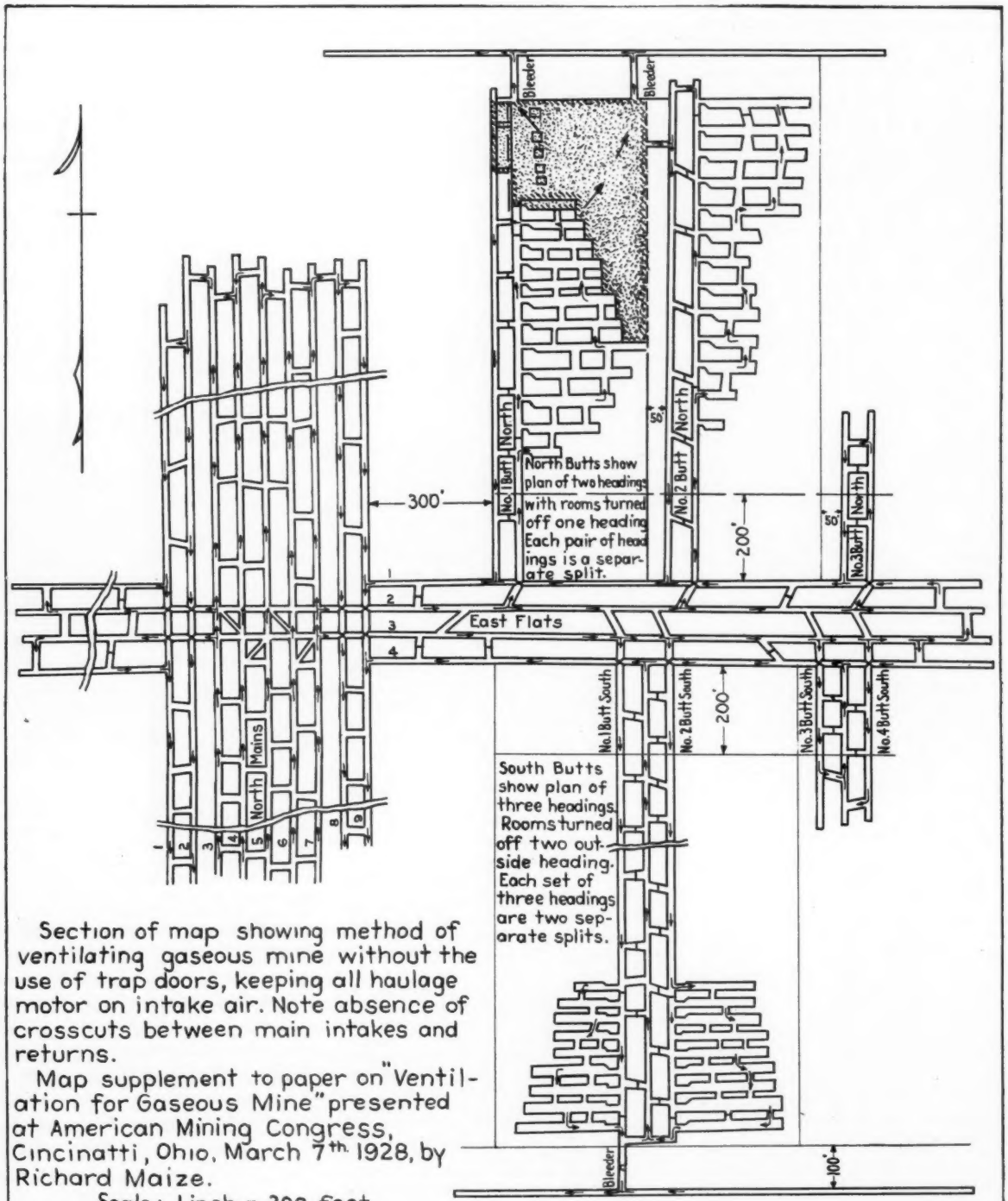
(14) In pillar workings, bleeders or drainage, rooms should be provided to conduct methane into main return; and, if necessary in pillar workings, boreholes should be drilled from the surface into the pillar falls to drain off the methane.

In addition to the ventilation necessary to keep a gaseous mine in a safe and healthy condition the writer is not unmindful of the fact that if the mine is dry and dusty, the road ways, traveling ways and air courses should be thoroughly rock dusted. In trackless headings and entrance to each panel or section, rock-dust barriers should be erected. Rock-dusting should be carried into all room headings. An adequate sprinkling system should be installed and proper connection made into each working place to keep the dust thoroughly dampened, and water should be sprayed on cutting chains of all mining machines in places or sections of the mine which are dry and dusty.

As a final check on the methane content of the main return air a continuous "Automatic Methane Recorder" could be connected with the main return airways and the instrument installed in the office near the entrance to the mine.

WALTER H. GLASGOW, *Secretary of Mines, State of Pennsylvania*, in discussing Mr. Maize's paper said:

"I would like to clear up a point on the second recommendation that a fan should have two separate driving units. I am not quite certain whether the author was referring to steam equipment or electric equipment, but in view of the many changes being made in recent years from steam to electric drives for fans, I think it important to mention here that the larger companies, with whom I am acquainted, have been installing only one electric drive equipment. But they have been very insistent on having two sources of power supply.



Section of map showing method of ventilating gaseous mine without the use of trap doors, keeping all haulage motor on intake air. Note absence of crosscuts between main intakes and returns.

Map supplement to paper on "Ventilation for Gaseous Mine" presented at American Mining Congress, Cincinatti, Ohio, March 7th 1928, by Richard Maize.

Scale: 1 inch = 300 feet

"I mean by that that they have a source perhaps to the north and one to the south, so that if anything should happen, either to the generating plant or to the distributing line leading into that driving unit you would have at least two chances to get your power for that equipment.

"I would say further in connection with the auxiliary gas engine, I don't believe it is the intention of the author to convey the idea that the auxiliary drive is to operate the fan at full speed. The companies that I know of have been making a practice of installing gasoline engines that can be switched on to the fan in a minute or less by a flexible coupling, but that engine is of small horsepower, only sufficient to drive the fan at a speed that will give enough air to allow you to get your men out of the mine safely within a period of several hours."

***C. B. BYRNE**, of the Pennsylvania Department of Mines*, pointed out that:

"In the Pittsburgh field we have found that even in the most gaseous mines it is rarely that a fire boss finds an accumulation of gas at the working face. That is entirely due to the method of ventilation used. Our ventilation work is done under pressure, our falls are under pressure at all times. We carry a lock system in ventilation where the opening of one door will not short circuit the current. A man would have to open two doors before he would stop the air current at the working face. That has worked out to our advantage in many cases.

"In the pillar walls, if you keep them under pressure, it doesn't take much pressure to keep them clear. I think if we would adopt a system of mining where the block would be cut entirely around by development work before you open the rooms you would save an awful lot of gas accumulation at the working faces.

"It is very rarely that you find gas at the working face of a room in a block that is surrounded by development work. If we have a block with development work and start our working faces producing rooms off that block, we cut down the gas content and make it more safe. If we keep our walls clear under pressure and carry a lock system of ventilation in such a way that the opening of one door will not short circuit any of the air traveling through, we will reduce the accumulation of gas at the working face. We don't have much of that in the Pittsburgh field.

"If you look in the fire-boss record, you will see there is rarely an accumulation of that kind. That is a thing that we have to take care of. Electricity and gas will not mix. They must be kept apart and the element of ventilation has been very much neglected by the Mining Board. The fan has been put in, but there has been no area or airways to give the air an opportunity to do the work, and the direction of the air current has not been taken care of to the point where it will not be short-circuited. Those are the things that we have to work out."

***DR. J. J. RUTLEDGE**, of the Maryland State Bureau of Mines*, said:

"Mr. Maize, as you will recall, said that the fan should have two separate and independent means of motion and in addition a third one—an internal combustion or gasoline engine. It seems to me that two would be sufficient. He could have electric power on one end of the shaft and an internal combustion engine on the other. That is the first comment I have.

"Next, he very properly said, he would have a reversible fan operating as an exhaust. He wants his fans reversible. Another important point, and this will probably bring some comment from the men here from Illinois, is that he wants the cross-section of his intake, on which is the haulage, larger than the return, and I think that is very proper. He will get a higher velocity on his return and will allow for the obstruction on the air on intake by haulage.

"I did not have the opportunity of seeing the drawing until a moment ago, but I was very glad that he brought out the fact that mines could be ventilated without doors. In fact, there are some mines so ventilated, and have been for some time. I note Mr. Maize takes cognizance of that fact. He also keeps his doors off the main haulage ways.

"Now, another fact that is hidden in Mr. Maize's paper is the amount of air in each separate split in proportion to the methane made in that split. This is a very important requisite. Those of us who are in charge of state mining departments and responsible for mine safety to the various commonwealths are often chided because we don't do certain things, yet there are many things that state departments do that are not known to the general public. And this clause that Mr. Maize refers to, namely, the 25,000 cu. ft. on each split where he has one-half of 1 percent of methane, is something in the safety line of which the general public knows little. If he gets any more methane in that split, he must stop some of the working places on it. I think this is a very wise provision. So far as I know, it is only enforced in some Pennsylvania bituminous districts, although it may be in other places. As I said, the general public doesn't always know these things, and hence fails to give the inspection departments due credit for what they have done.

"Mr. Maize also believes in a large volume of air, as well as a slow-moving current, especially at the working face, so as to give proper effect to the diffusion gases. I think he is very wise in bringing that in.

"As you will note, he also referred to the use of the Burrell indicator as a check on the air analysis.

"There has been a tendency in many states, especially where mines are opened in thin coal seams, and sometimes in relatively thick coal seams, to multiply the number of air courses. Some have even used nine parallel air courses, each one of them with its added amount of falls. It would be better policy, in my judgment, to make larger air courses or to leave the track in the air courses and to load up the falls, or to arrange for spreading out the falls and running the air over the top of them. I believe it is much better to have one large air course, free from falls, than several small air courses clogged by falls. If you were in some states, you would have to consider the yardage cost, and you wouldn't have to be told that you should not unduly multiply the number of air courses.

"I am sorry I didn't have an opportunity to point out to you the use of the bleeders in bleeding the gas off the pillars, which is an extremely valuable measure and interesting to those in other fields who may not be familiar with this practice.

"Just in closing I want to say that in our recent examination we ran into candidates for first-class certificates of competency as mine foremen, which examination involves a knowledge of gas, and some of the men who had worked in gaseous mines—very gaseous ones, where electric cap lamps were used exclusively—confessed their inability—their utter inability—to detect gas, because they hadn't had the opportunity of using a flame safety lever. That is one difficulty that our mine examining boards meet with in regions where electric cap lamps are employed."

A corner at the Cincinnati Exposition

WORLD COAL OUTPUT

World production of coal of all grades in 1927 is estimated by the Bureau of Mines as 1,475,000,000 tons. Approximately 197,000,000 tons was lignite and 1,278,000,000 bituminous and anthracite. Lignite production, the largest on record, increased 53 percent over 1913. Anthracite and bituminous coal also was at a record high, but increased only 5 percent over 1913. The 1927 figure compares with 1,365,000,000 tons for 1926 and 1,372,000,000 tons for 1925.

The 1927 figures give the United States 471,556,000 tons of bituminous and lignite and 73,164,000 tons of anthracite, Great Britain 259,516,600 tons of all grades, Germany 153,597,600 tons of coal and 150,805,711 tons of lignite, France 51,779,300 tons of coal and 1,067,400 tons of lignite, and Belgium 27,573,550 tons of all grades.

CAPACITY *and* DESIGN *of* MINE CARS*

By C. E. WATTS †

Uniformity Of Design Essential —Standard Tread And Flange Advocated—Character Of Steel Quality And Importance Of Bearings Emphasized

WHEN first approached about the matter of preparing a paper for this meeting, on the subject of "Design and Capacity of Mine Cars," I felt that a new paper by myself on this subject would be superfluous on account of the one which I presented at the meeting in 1926. However, as it was felt desirable to have something on this particular subject at this meeting to round out the whole sessions' program covering "Power and Transportation," I agreed to try to present additional information based upon our extended experience. What follows therefore includes a brief résumé of the salient features presented in my former paper with the addition of other information and data which has been gathered in the course of the past two years' work in connection with operation and maintenance of mine cars.

A. C. Callen, chairman of the session on Power and Transportation

Conditions encountered in and about coal mines necessarily are varied, therefore the detailed designs of cars for different mines present their own particular problems and render impracticable the adoption of strict standards for all details. In general cars of composite or all steel construction are replacing the old all wood type, and the gate end in all types is being superseded by tight end design. While the all wood car is somewhat cheaper to construct, the composite and all steel type car is much sturdier, has greater capacity for same overall dimensions, and in the long run is cheaper to maintain than the wooden car. The recent development of a successful and comparatively inexpensive power and gravity rotary dump leaves little argument for the continuance of gate end construction in the future as the gate feature reflects adversely upon the weight and strength of any car.

In times past it has been the custom of many operators, when in need of mine cars, to leave much of the matter of detail design to the prospective car builders, the operator fixing only the general features, such as wheel base, and sizes, wood or steel construction, tight or gate end, and overall dimensions, with possibly a few minor details. Such procedure requires the manufacturers to supply their own plans, embracing these general features and backed up by each prospective builder's solution of details, with the natural result that varying quality of materials, ideas of design, and such features as favor lowest cost to the particular bidder establish the prices submitted to the customer, who makes his selection. The continuance of this policy is sure to result in the accumulation, by the consumer, of cars dissimilar in detail, and also retards improvement or progression in quality and design of that particular car. These disadvantages can be overcome by the consumer owning a complete set of working plans, and material specifications covering the car in minute detail, for use in obtaining quotations. This places all bidders on an equal basis with respect to material and design entering into the construction of the car, which results in establishing and maintaining cars of similar detail and encourages improvement, for no matter how carefully details and specifications are originally established, the practical use of the cars over an extended period of time will demonstrate where improvements can be made. The ownership of these plans and specifications makes the accomplishment of such changes in future purchases a simple matter.

Where full or part steel construction is used, all sheets should contain a certain percent of copper, as unquestionably copper bearing sheet steel has an appreciably longer life than plain O. H. steel in this class of service, and its use is therefore fully justified.

Although the different types of bearings, such as plain, ball, flexible and tapered roller are in use, each requiring a grade of steel peculiarly fitted to its particular type, there are no standards of specifications descriptive of a suitable steel for any of them. I might say I have had this matter brought to my attention in a very forcible manner, a short time ago where we put in a certain type of anti-friction bearings on cars, and had the wrong axle steel to accommodate that particular type of bearing. The correction of that error cost more than $8,000. The lack of knowledge of this subject can and does result in costly experiences and sometimes leads to erroneous impressions, opinions and decisions by those whose business it is to select and purchase mine cars.

As to wheels—a standard form of tread and flange contour has been recommended by the Standardization Division of the American Mining Congress, which standard is the result of the consideration of 141 different wheel contours submitted by the operators and manufacturers of mine car wheels in this country. There is no reason why this standard should not be used and its benefits accrue to all users.

Car links and pins constitute items of no mean importance, particularly as car sizes and train weights appear to be universally in the increase. It is questionable, how much expense is incurred in the industry from wrecks and accidents caused by the failure of links or pins, and the few inquiries which I have made amongst mine officials and manufacturers regarding this item indicate that they give little real thought to the quality and fitness of steels for this service. A car link, to be reasonably dependable, must be ductile, free from welds, and designed with a factor of safety of at least 10. Pins are universally too small and of too low carbon content. Since a link is subject to different stresses than a pin it naturally follows that different steel would be required for a link than for a pin. Where duty is hard it is good practice to subject both to periodical annealing and test to counteract crystallization, detect imperfections and lessen the hazards to haulage systems due to failures at these points. There is nothing to prevent, and every reason to advocate the specifications for link and pin steels.

C. E. Watts

In connection with the item of bolts of which a considerable number enter into the construction of any car, care should be used to avoid the use of those having ¼ in. length measurements. That is bolts 4¾, 8¾, etc. They are not as readily obtainable in the markets as bolts of ½ in. or even 1 in. length measurements, such as 4, 4½, 8 and 8½ in. lengths, and tend to confuse and complicate the mine stock when carried in ¼ in. length multiples. One of the features recently encountered by the writer in overhauling a thousand cars were hexagon nuts found on journal box bolts. The work was appreciably more costly than would have been the case had square nuts been used, because of the difficulty in rounded corners. Square standard sized nuts and bolts of 1 in or ½ in. length denominations are a simple thing to incorporate in car construction specifications.

The foregoing are a few representative features which should be incorporated in specifications of this kind.

Although a mine car is subject to very rough usage and receives many unavoidable hard knocks, which necessitate rugged construction, and also result in a unit which is very heavy

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* Presented to 5th Annual Convention, Practical Operating Men, Cincinnati, O., May 8, 1928.

† Mechanical Engineer, Berwind-White Coal Mining Co.

in proportion to the weight of live load carried, it seems to me that there is much room for improvement in this connection, especially in the design of composite tight end types.

The common practise now is to build cars of 50 to 100 cu. ft. capacity whose ratio of live load to total weight ranges from 60 to 66 percent, i. e., taking a car of say 90 cu. ft. capacity, whose weight empty is 3,400 lbs., carrying 6,300 lbs. of coal, making 9,700 lbs. as weight of car and coal, the coal represents a little more than 64 percent of the loaded car weight.

In order to lighten the car and at the same time to retain the necessary strength, malleable iron castings could be used in place of cast iron parts. Alloy or heat treated steel axles in place of untreated carbon steels might be used; wheels of greater strength and similar wearing qualities than cast iron are now available, and since it has been conceded that train resistance on average mine haulage systems is practically no greater with cars equipped with 14 in. diameter wheels than with 16 in. wheels, this in itself is a source of considerable weight reduction which should be considered. Inasmuch as copper content sheet steels withstand corrosion better than O. H. steels, the copper content sheets could be used and made correspondingly lighter. Their strength and stiffness could be increased by pressing crimps into them, thereby eliminating some weight in bolts and body bands or braces. The body bands themselves now made of rectangular cross section material could be so constructed of other section which would be just as strong and suitable for the service and considerably lighter.

Cumbersome, flapping brake rigging could be replaced by close, neat fitting and lighter apparatus for braking.

The use of tight in place of gate end alone is equivalent to a saving in weight of at least 150 lbs. in a car of this size. These and other points are legitimate sources of weight saving without infringing upon the capacity or necessary strength in car construction. Benefits which would accrue from a reduction of four or five hundred lbs. weight on a car of this size are numerous and its attainment is highly desirable.

The question of car body capacities for mines of limited cross sectional heading area and room height seems to have crystallized into designs of maximum length, width and heighth consistent with loading facilities, top and side clearances; while for machine loading in thick seams, car bodies of unprecedented and ever increasing capacities are being developed.

Axle diameters must be increased in proportion to the increase in size and weight of the car, and since total resistance to movement increases as the weight on wheels is increased, it naturally follows that heavy cars are much more difficult to manhandle than the lighter cars. In recent years this matter has received much attention from the anti-friction bearing companies, with the result that anti-friction bearings which not only appreciably reduce journal friction, but also contain other advantages over plain bearings which fully justify their use in this class of service and are now being extensively used. Of course advantages of anti-friction bearings over plain bearings in so far as reduction of train resistance alone is concerned, decrease as the grades increase, and

Roller bearing equipped mine car used by Berwind-White Coal Mining Co.

would practically disappear were grades sufficiently increased but their marked advantages in manhandling and spotting cars on level track or average mine grades are very decided. Other great advantages of the anti-friction bearing are avoidance of wheel hub wear, and decreased cost for lubrication. In certain types axle wear is also eliminated.

The data shown in the accompanying table were compiled by the writer in connection with the study of mine car bearings and lubricants at The Berwind-White Coal Mining Company's Mines at Windber, Pa., and should answer conclusively the question of lubricating costs on bearings of the types shown.

The significance of the figures in col. 6 is more forcibly brought out by the analysis of greasing costs, when car capacity and tonnage handled by the 27 cu. ft. car on plain, and the 52 cu. ft. car on tapered roller bearings is considered.

By replacing the smaller with the larger car it would be necessary to supply a total cu. content somewhat in excess of the total cu. content of the smaller car to compensate for decreased flexibility of the system due to the larger units. This increase should be about 5 percent. The equivalent car capacity of the 7,766 small cars would be 4,025 large cars, based upon an average live load carried of 2,000 lbs. and 3,860 lbs., respectively. The additional 5 percent for flexibility would bring the total number of large cars to 4,225.

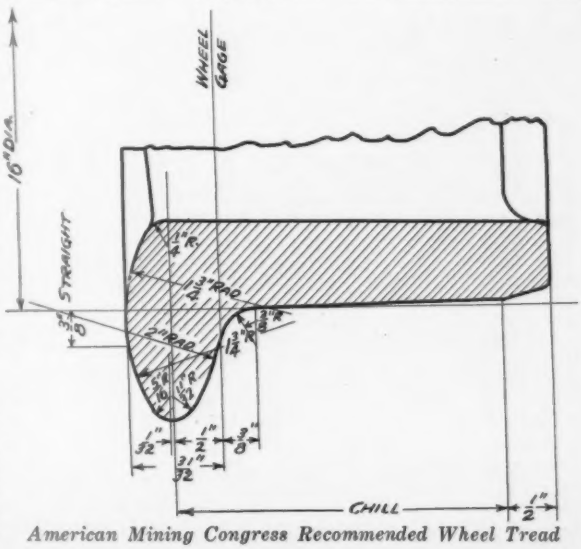
The yearly greasing cost of the latter would amount to $1,403.00 as against $18,558.00 for the smaller cars. This

TABLE I

Lubricating costs, using various kinds of bearings and lubricants

Average weight of 27 cu. ft. all wood car loaded is 3,475 lbs.
Average weight of 71 cu. ft. all wood car loaded is 6,560 lbs.
Average weight of 52 cu. ft. composite car loaded is 6,585 lbs.
The average mileage per year of each car is approximately 1,800 miles.

1	2	3	4	5	6	7	8	9
Kind of lubricant used.	No. of cars in service.	Water level content of car body in cu. ft.	Cost of lubricants used per year.	Cost of labor to apply lubricants per year.	Total cost of lubricant and labor per year	Total cost per car per year in dollars.	Type of bearings on cars.	Date of completion of year's test.
Car Oil	7,766	27	$7,614.36	$10,944.00	$18,558.36	2.39	Plain	3-1-24
Car Grease	2,651	71	3,025.05	2,400.00	5,425.05	2.05	Plain	3-1-24
Approved Grease	3,560	52	749.60	434.64	1,184.24	.332	Tapered Roller	6-30-27



American Mining Congress Recommended Wheel Tread

difference of $17,155.00 in the cost of lubrication as between these two types of cars assists materially in carrying the capital investment required for the installation of the larger cars. I would say, in order to vindicate those last paragraphs, a little study of Table No. 1 will be necessary. I was a long time getting the data in that table, because it takes a long time to gather such data as that to get it anywhere near right. I had the patience to follow it out for three or four years, and I believe those figures are very representative of the lubricating costs on the types of bearings designated.

(In answer to an inquiry, Mr. WATTS stated that:)

"We have in use about 4,360 steel cars now. The first 600 were the plain or open hearth sheet metal. All the remaining cars have .015 to .025 copper content in the open hearth steel. That is melted into the material as it is made in the furnaces. That results in an increased cost of about $2.25 per ton of sheet metal, or at least it did at the time of purchase.

"We find that the sheet in the original 600 cars, which are now six years old, shows a different method of deterioration, or different physical appearance in deterioration, than does the copper-content metal. The plain open hearth sheet oxidizes and the scale forms in large sheets. Over a period of a couple of years you will find that formation presents itself in large sheets which will scale off, while with the copper bearing sheet we don't find that particular action. The copper bearing sheet shows, I would say, a pitting or corrosion all right, but it doesn't get that big, heavy sheet incrustation that comes off.

"We don't know how long either the open hearth or the copper-bearing sheet will actually last before the cars are done, but we expect a life of at least 12 years from a copper-content and about eight years from the plain open hearth sheets.

"We have 1,050 cars contracted for during the last week and they contain that percentage of copper-content in the sheets. The percentage of copper is .015 to .025. We have specifications covering all the details of construction. As time goes on, we add or change sometimes on those details as found advisable from experience in service of the cars."

***W. D. HOCKENSMITH**, Hockensmith Wheel & Mine Car Co., Penn, Pa.*, in discussing Mr. Watts' paper, said:

"This is a very interesting paper. Mr. Watts has given a very thorough study to the car question. I am interested in mine cars first, last, and always. That is the line of work which we try to keep track of. Particularly, I am interested in the lubrication situation as to wheels and cars and the savings to be gained thereby.

"Some four or five years ago we started an investigation on bearing equipment, wheels, and so forth, and determined (as I believe we discussed last year) that the diameters of wheels didn't have very much to do with it. The minimum diameter wheel isn't much of a factor just so you get a clearance from the tracks. It seems to require about the same amount of power to move cars with large wheels as with small ones, keeping within the range now in use. The 18-in. wheel seems to be out of date. A 14-in. or 16-in. wheel, preferably a 14-in., if it can be used, is the size generally installed in new equipment. If you can keep your tracks clear, 12-in. wheels are satisfactory with heavy rails, which adds somewhat to the clearance. We find that mine motors require as much, if not more, clearance than mine cars. The advantage of 12-in. wheels over 18-in. wheels is about 3 in. in height, and this added to the top of the car adds materially to the capacity.

"There is a question as to the best type of bearings for wheels. In a series of tests made by the Department of Mines a bulletin was published in which bearings were loaded in different ways. They placed a couple of tons of load on a shaft and hung it free to rotate. In this rotation there was considerable saving in the power necessary to move the load, but there was not a very great difference between the plain and roller bearing after a load was once started. When loads were placed on cars on track there was a great amount of difference in power necessary to move the same load. It developed that the flange of the wheel and the rolling of the tread on the rail consumed about two-thirds of the total friction of the car. In other words, only about one-third of the total friction of the car could be charged to the bearings in the wheels. All wheels have about the same flange and rolling friction. I wish here to defend the fact that plain bearing friction has not been responsible for all the excess friction troubles in the past, and when plain bearings and roller bearings are checked carefully you will discover this. We will admit that the roller bearing companies have demanded and the wheel manufacturers have produced a superior wheel—that is, better finished—which will reduce very much the excess friction. Plain bearing wheels have been very much improved during the last few years, and I believe will come into more general use.

"In many ways the lubrication problem of plain bearing wheels has been neglected. There are plain bearing wheels now being offered that can be lubricated with a fluid oil about the consistency of heavy machine oil. These wheels are so designed that they will hold this lubricant, and you will be able to secure from 30 to 90 days' operation with one application, depending entirely on the ton-miles that the cars travel, and this should be the basis of all lubrication. We have found that some mine cars travel two to three times as far as others and carry from one to two times the load in the same number of days.

"Hand handling of cars is rapidly being discontinued from the fact that cars are now being built to carry from 4 to 10 tons of coal. These cars will have to be placed for loading by motors. Coal in the future will be hauled in large capacity cars.

"Railroad companies are satisfied with plain bearing equipment and are only experimenting with roller bearings in order to reduce their starting costs, which is not a serious item in mine car service. We admit that plain bearings require more power to start, but after they are once in motion there is very little difference in the power necessary to keep them moving.

"One statement in the bulletin published by the Department of Mines was as follows: 'After our investigation we believe there is a good opportunity for a better design and better finished plain bearing wheel.'

"The oil used in plain bearing wheels can be purchased from 20 to 24 cents per gallon, or 2½ to 3 cents per pound, and with the time of application of lubricant extended from 30 to 90 days I believe this will help solve the lubrication problem. Lubrication seems to be one of the principal advantages in the present roller bearing equipment.

"When you have to add $20 to $40 per car for roller bearings, it causes mine owners to look carefully into this, as expense is one of the items that must be reduced. All wheels wear out in the tread and flange about equal, and roller bearings cost somewhat more than plain bearings for replacement. The extra expense of servicing roller bearings has not yet been figured or added as an extra cost, and this must also be given consideration in the final analysis."

(In concluding the discussion of this paper, Mr. Watts said:)

"Mr. Hockensmith's statement fully vindicates a statement made in this paper—the design of bearings for mine cars is beginning to interest the car designers. If they do design a plain bearing which will materially improve the performance of the old plain bearing type and approach the performance of the roller bearing or anti-friction bearing type of today, there will be something gained and it will be a very creditable performance.

"The past history of plain bearings has been that about three-fourths of the lubricant, when applied to the wheel, hits the ground and about one-fourth of it stays in the wheel; the one-fourth that went into the wheel runs out before the car has made a couple of trips. This result is largely due to incorrect design of wheel hub. This is the reason why the plain bearing couldn't make a better showing. With the design of roller bearings, or anti-friction bearing types, refinements in the design have been practiced, with the result that the lubricant that goes into those bearings doesn't leak out. It stays in there. It does the work that it is intended to do.

"I have bearings in service (some 18,000, tapered roller bearings, that operated 18 months on one lubricating application. That is not by any means the limit that could be expected or could be obtained.

"In an 18-month period of lubrication the wheel is not at all in distress for the want of lubricants.

"I would not be afraid to say that a mine car could run, not for a period of time, but for a distance of miles. I would not be afraid to say that an anti-friction bearing of a proper design could run 4,000 miles on one application of lubricant. Whatever time that may take in mine-car service, I don't know. It may be six months or four years. It would run 4,000 miles on one lubrication without danger of injury or increase in bearing friction.

"That is a point for the plain bearing designers to strive for, and I believe they can make good headway toward the cheapening of lubrication costs. It is quite an item. Not only the cost of lubrication but the resulting damage for the lack of it that comes to cars, wheels and bearings, that represents a lot of cost."

A HAULAGE SYSTEM *with* GATHERING LOCOMOTIVES ONLY*

By R. L. ADAMS†

An Unusual System Where Each Locomotive Gathers Its Loads From Working Faces Into Trips Ranging From 7 To 14 Cars, Proceeds Directly To Shaft Bottom, Picks Up An Equal Number Of Empties, And Returns With Them To Working Faces

THE prevailing system of locomotive haulage in coal mines of the nation is that in which locomotives of comparatively small size are used for gathering and larger ones for hauling the trains or trips from the point of assembly to the point of hoisting or dumping. In a well-ordered system of this kind side tracks or partings are provided as near the working faces as convenience will permit, so that the gathering locomotives will be required to travel a minimum distance to perform their work of distributing empties and gathering loads. If the plan works well, there must be sufficient mine cars to keep loaders at the face busy while loads are being assembled on the partings, hauled to the outside and dumped, and empties returned and distributed.

R. L. Adams

Even in the best organized mines using this familiar system it is rarely possible to so coordinate the work of gathering, main line haulage, and hoisting or dumping that there are not frequent delays to one, two, or all three operations during the day's run, due to improper functioning of some one of the three. It is the purpose of this article to describe a haulage system which eliminates one of these three sources of delay.

Old Ben Coal Corporation's mine No. 8, in Franklin County, Ill., began commercial production in September, 1910. Combination trolley and cable reel locomotives were used from the beginning, gathering from the faces and delivering to the hoisting shaft bottom. As more working places were opened and their distance from the shaft increased, more gathering locomotives were added until the length of haul seemed to justify the installation of a main line system. Plans were made for building inside partings, purchasing two main line locomotives, additional mine cars, and the reconstruction of track arrangements near the shaft bottom and elsewhere to fit the new conditions that would be imposed by the heavier locomotives and longer trips. The temporary haulage plan had worked so well up to that time that the management was reluctant to abandon it for no better reason than that the length of haul had reached the point where it was customary to use heavy locomotives. A study of the whole matter indicated that by the purchase of two more gathering locomotives and construction of two passing tracks, one on each of the main roads entering the shaft bottom, the day of installing heavy locomotives could be set ahead indefinitely. By the latter plan considerable capital expenditure would also be saved, and it was therefore adopted. Since that time nothing has occurred to justify changing the system. Every locomotive gathers its loads from the working faces into trips ranging from 7 to 14 cars, proceeds directly to the shaft bottom, picks up an equal number of empties and returns to the working faces.

By the year 1920 the daily production had reached an average of 5,600 tons. In the meantime the two passing tracks had been extended until the main roads were double tracked for approximately 1 mile from the shaft bottom in both directions. The tracks are on a single entry, which was widened to a minimum of 16 ft. to provide room for the second track. Additional cars and locomotives had been put into service from time to time as required. The above daily production has been maintained up to the present time without any radical change in the haulage, although five loading machines have been added during the past two years.

Of the 12 Old Ben Coal Corporation mines in southern Illinois, nine were fully developed and on a production basis when acquired. Three of them were opened and developed by that corporation. All of the former have main line haulage systems, while the latter use only gathering locomotives. Four mines, two of each group, are about equal in daily production. Mining conditions, hoisting facilities, and haulage grades are about the same in all of them. A recent check of haulage costs over a period covering the past two years showed a margin of approximately 2 cents per ton in favor of the two mines having gathering locomotives only.

Experience with both systems during the past 16 years has brought out certain advantages of the gathering locomotive system, some of which are:

(1) A less number of mine cars are needed, the difference being the number required to fill all inside partings of a main line system.

(2) Waiting at partings of two or more gathering locomotives, or the haulage locomotive serving it, is entirely eliminated.

(3) Wrecks are less severe because of the smaller trips and are more readily cleaned up because one or more extra locomotives are quickly available.

(4) Better supervision of haulage men, since every locomotive crew comes to the shaft bottom periodically throughout the day.

The reports of the United States Geological Survey indicate that more than 80 percent of the undeveloped water power of the country is in the Pacific Mountain and South Atlantic states. These states contain less than 22 percent of the population of the country. Of the other 20 percent of undeveloped water power in all the rest of the country, much is not economically feasible of development at present and most of that which is economically feasible can not be developed owing to legal or political restrictions.

* Presented to Fifth Annual Convention, Practical Operating Men, Cincinnati, Ohio, May 8, 1928.

† Chief Engineer, Old Ben Coal Corporation.

UNDERGROUND TRANSPORTATION *at* EBENSBERG COAL CO*

By R. M. FLEMING †

Haulage Methods In Mine Producing 4,000 Tons Per Day—Seam 3½ Feet High With Average Dip Of 5 Percent—Rock Tunnel Driven 2,200 Feet From Outside To Center Of Active Mine Workings—Maximum Main Line Haul Of Three And Half Mines—Locomotives Of 15 And 22½ Tons—Trips Of 73 Cars—Telephone Dispatching

IT IS the intention of this paper to describe the transportation system at Colver, with particular attention to the performance of haulage locomotives. This mine is known as the Ebensburg No. 1 mine of the Ebensburg Coal Co. It is located at Colver, Cambria County, Pa., in the heart of the low volatile coal fields of Central Pennsylvania. The mine was opened in 1911 and is at the present time producing over 1,000,000 tons of coal yearly, at the rate of 4,000 tons daily.

The seam of coal mined is the lower Kittanning or "B" Seam, which averages 3½ ft. in thickness. Except for local irregularities the bed is fairly uniform within the boundaries of the property. With the exception of a small area in the eastern portion of the property, the coal lies along the western flank of the Laurel Hill Anticline, with an average dip of 5 percent toward the western boundary of the property. There are no outcrops of lower Kittanning coal within the company's property lines. The nearest approach to the surface is in a valley near the central western boundary. As this valley was most accessible to the railroad, the property was developed from this valley.

R. M. Fleming

The mine was opened by driving a rock tunnel 2,200 ft. long on a one-half percent grade to meet the coal seam as it rises toward the anticline. This intersection of the tunnel with the coal seam is the central point of the inside layout. Haulage roads from all sections of the mine meet at this point. A set of main entries continue in the coal on the course of the tunnel straight toward the eastern boundary dividing the upper half of the property into two parts. Beginning at the junction point headings are driven to the right and to the left from the main at intervals of 1,800 ft. These headings continue along the flank of the anticline to the eastern or western boundary lines. At intervals of 425 ft. room entries are turned up the hill. From the room entries rooms are turned on 60-ft. centers. The portion of the property lying below the junction point constitutes a little more than half the total area of the property. This portion is developed in a similar manner to the upper portion. From a point on the first left-hand section entry 1,000 ft. from the junction point a set of main entries has been driven toward the northern property lines. This set of entries divides the lower portion of the mine into two approximately equal areas. At intervals of 2,000 ft. along the main dip heading section entries are turned to the right and to the left to continue to the eastern and western property lines. Room entries and rooms are turned in the same manner as they are turned in the upper portion of the mine. The mine is thus divided for all practical purposes into four approximately equal sections, two of which lie above the tunnel and two below the tunnel. Haulage roads from all four sections meet at the inner end of the tunnel.

A haulage system has been devised for moving coal from the room faces to the tipple for the mine just described which is remarkable mainly for its simplicity and effectiveness. Coal is transported from the room face to the tipple in three steps. Cars are handled between the room face and the room heading by manpower except where local conditions make hoists necessary. Gathering locomotives of 10, 12 and 15 tons assemble the loads into trips and place them on side tracks. These side tracks are placed on section entries in close proximity to the active workings. The trips are transported from the side tracks to the tipple without stop by 15 and 22½-ton locomotives. The movement of all haulage locomotives is under the direction of one man who is stationed in the mine yard just outside the tunnel mouth. This man is in telephone communication with all side tracks and junctions. This central control serves to eliminate lost motion and delays in the movement of coal toward the tipple.

In any haulage system the roadway is of prime importance. At the Ebensburg No. 1 Mine the general layout has been arranged to take advantage of the grades. On main entries the average grade is 4 percent with a maximum of 6. On section entries grades are usually about 2 percent in favor of the load while in room headings grades vary considerably from 2 percent to 6 percent in favor of the loads. Rooms are generally on sufficient grades to drain properly. The general plan is not changed when local conditions interfere with these grades. If the interruption occurs on a permanent or important haulage road money is spent to grade the road bed to a uniform grade. Rails and trolley wire are selected of sufficient size to endure the haulage demands. Where there is sufficient volume of traffic roads are double tracked. When the road ways have been placed in proper shape the next important feature in haulage is the selection of proper equipment.

A definite policy of selecting equipment to meet haulage conditions was begun in 1924 when roller bearing, wooden

* Presented to Fifth Annual Convention Practical Operating Men, Cincinnati, Ohio, May 8, 1928.

† Engineer, Ebensburg Coal Company.

LOCOMOTIVE DATA

Loco. No.	Size of Locomotive	Trips Per Day	Cars Coal Trip	Cars Rock Trip	Round Trip Dist.	Ton Miles per day	Unfavorable Grade
1	15 Ton	7	64	9	7 Mile	7,366	1,200' 3%
2	15 Ton Baldwin Westinghouse	8	51	1	2	1,706	2,000' 4%*
3	22½ Ton Baldwin Westinghouse	9	55	5	3	3,591	4,000' 4%*
4	22½ Ton Baldwin Westinghouse	8	63	3	2	2,165	6,000' 4%*
5	15 Ton	6	53	2	5½	3,720	.....
6	15 Ton	7	48	1	4½	3,178	.....

* Assisted on grade by 15 ton pusher.

bottom, steel mine cars began to replace the old wooden mine cars. Only a few of these cars were purchased at first and equipped with several types of bearings. With each purchase of additional cars the weak points were gradually eliminated until at the present time 1,710 mine cars are in operation, of copper bearing steel sides, wooden bottom construction mounted on Timken roller bearings. These cars weigh 2,700 lbs. and have a capacity of 1½ tons. With the growing use of these steel mine cars it became necessary to build better haulage ways and with better haulage ways it became possible to haul larger trips. Larger trips required stronger haulage locomotives. A policy of transportation in large units was thus developed.

Haulage locomotives are selected with sufficient strength to do a day's work without undue strain. That the locomotives selected have met the demands imposed upon them is testified by their performance. In the accompanying table under "Locomotive Data" the average daily performance of each of the six main line locomotives is shown.

Locomotive No. 1 in the table has the longest haul of all. From the side track to the tipple the distance is 3½ miles. This locomotive averages 7 trips or 50 miles per day and hauls 73 cars per trip.

Locomotive No. 2 makes 8 trips per day with 52 cars per trip over a round trip distance of 2 miles. Two thousand feet of this trip is on a 4 percent grade. A 15 ton pusher assists this locomotive up the grade. The same 15 ton pusher helps locomotives No. 3 and No. 4 up the grade.

Locomotives No. 3 and No. 4 were purchased especially to handle 60 car trips on a 4 percent grade. With the assistance of a 15-ton pusher these two 22½-ton Baldwin Westinghouse locomotives have been averaging 8 to 9 trips per day with 60 cars per trip over a round trip distance of 2 to 3 miles of which 4,000 to 6,000 ft. is on a 4 percent grade. These locomotives have been operating since last September and so far have required nothing in the way of repair except brake shoes and tires.

The burden which these two locomotives carry was formerly borne by three 15-ton locomotives. As the distance increased the smaller locomotives became overpowered. The cost of replacing burned out coils became excessive. Production was continuously being interrupted by the burning up of one or the other. When these interruptions became too frequent the 22½-ton Baldwin Westinghouse locomotives were selected to take up the work.

These locomotives have several features that are worthy of description. The frame is of the open type three bar cast steel side frame, which makes the locomotive very rugged without unnecessary weight. Mounted in this frame are three 90-hp. Westinghouse commutating pole motors. Each motor is geared to one of the three axles with a single reduction. The remarkable feature about the power units is the confinement of so much capacity in so limited a space. The locomotive was constructed to fit a 36-in gauge track with the overall height limited to 4 ft. 1½ in., width 5 ft. 4 in. and length of 21 ft. 1 in.

The motors are controlled by a two drum controller. This control is of the flexible semi-magnetic, series-parallel type. The reverse drum has one operating position on each side of the off position which determines direction of motion. The main drum has five accelerating positions and one running position with the motors in series and four accelerating positions and one running position with the motors in parallel. The two drums are interlocked so that the main drum must be in the off position before the reverse drum can be moved and the reverse drum must be in one of its operating positions before the main drum can be moved. The main circuit is not broken at the segments and fingers of the master controller. There are nine unit magnetic switches actuated by magnets. Motors are connected in series of parallel by two of these and the others act as accelerating switches. The switches are closed by magnetic action and opened by gravity. Renewable contact tips form a rolling contact under the action of a finger spring which also acts as a kick off when the switch opens. This type of control confines the arcing to the unit switches which are especially designed with a large current carrying capacity.

All of this electrical equipment is suspended from the frame which is in turn supported by semi-elliptic springs carried on the journal boxes. Two of the wheels on each side are side equalized and the other two are cross equalized, thus providing a three point suspension which makes the locomotive follow the irregularities of the track.

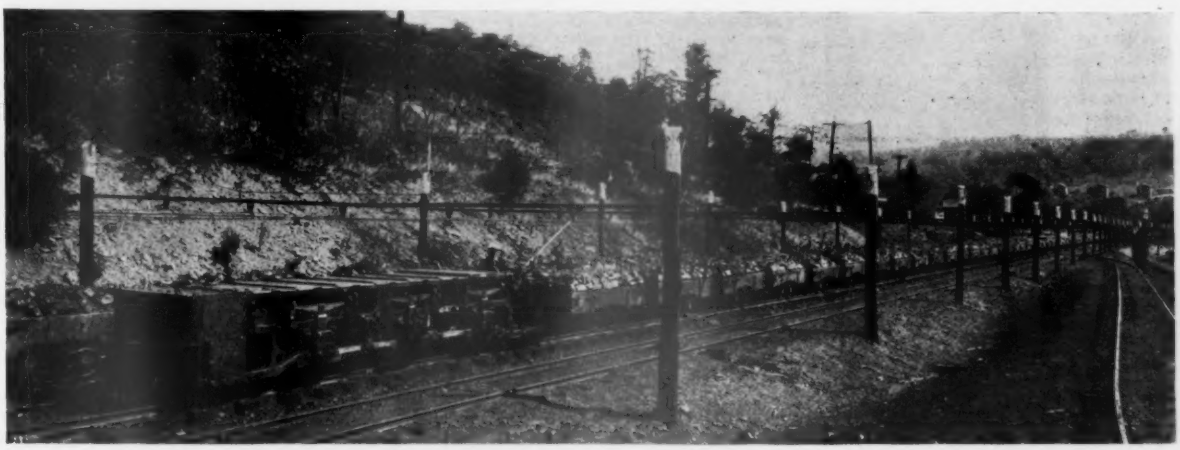
There are three sets of steel tired wheels 36 in. in diameter. Two pair are flanged and the center pair is without flanges to permit easy travel on curves.

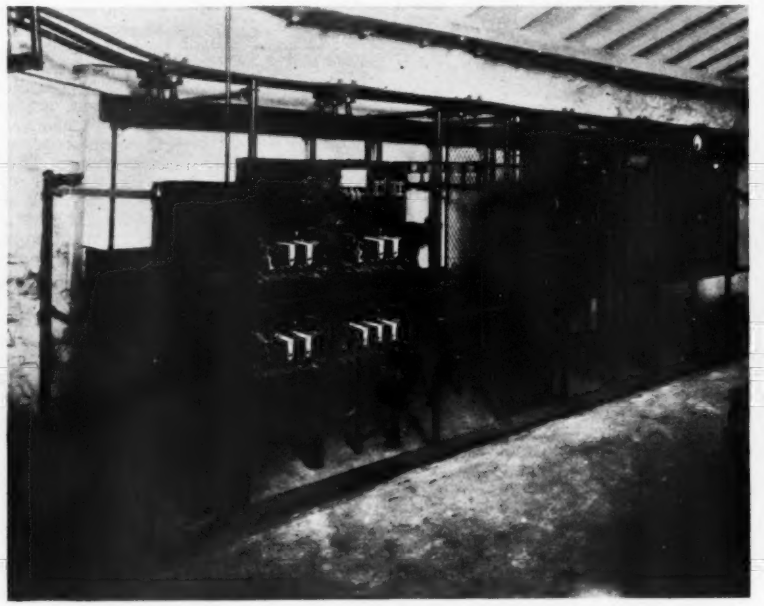
No difficulty has been experienced in keeping these locomotives on the track. They have performed consistently and satisfactorily the work laid out for them.

The remaining two locomotives No. 5 and No. 6 are doing satisfactory work on round trip hauls of 5½ and 4½ miles. As the grades on these roads are in favor of the loads there is nothing unusual in the performance.

As was mentioned in the beginning the haulage system accomplishes the movement of coal to the tipple in a very effective and simple manner. The truth of this statement is demonstrated by the results. Coal is being transported at the rate of 4,000 tons daily from a 3½ ft. seam by six main line locomotives and 1,710 mine cars of 1½ ton capacity. That there is no lost motion in the system is testified by the number of trips made and by the fact that the average output per loader is 9½ tons of coal per day.

These satisfactory results are accomplished by the coordination of several factors. A general scheme was adopted to take advantage of natural grades. Haulage ways are constructed for permanent use, during the life of a section. Equipment is selected with power enough to do the (*Continued on page* 546)





Close-up view of control panels to one pump

PUMPING *at the* PHILADELPHIA & READING COAL & IRON COMPANY

By J. T. JENNINGS †

Magnitude Of Pumping Problem Is Indicated By Fact That Average Ratio Of Water Pumped Is 12 Tons To Ton Of Coal Mined, Which Increases To 20 To 1 In Wet Season—Recent Survey Shows Automatic Pumping Plants Save Million Dollars Annually Over Old System

ONE of the major problems in Anthracite Mining is pumping. Regardless of whether the mine is operating or idle, large quantities of water must be handled. During normal times the average ratio of water pumped to the surface is about 12 tons of water per ton of coal mined, and, in wet seasons, the peak load of pumping climbs to 20 tons of water per ton of coal mined and even higher in the southern field. To visualize what this water problem means to the operating companies, we need only consider the factor of power requirements involved. The annual production of anthracite coal runs about 75,000,000 tons, making a pumping capacity of 412,000 g.p.m. with a load of 60,000 hp., or in electrical energy 1,200,000 k.w. hr. per day, making an annual power cost of about $5,000,000. Obviously, the investment in pumping equipment is large, labor costs and power costs high, the pumping plant becoming a very important factor as mining operations get deeper.

J. T. Jennings

For about 100 years steam pumps and water shafts have been employed to handle this situation; all, however, possess costly and objectionable features both from an operating and economic standpoint. When electricity was introduced in mining, it was soon recognized as a superior power to that of steam for underground work. The facility with which it could be transmitted, handled, and applied to the great variety of conditions encountered was appealing to the mine managers, who were far-sighted enough to visualize its possibilities, and the degree of progress made is attested by the complete electrical mechanization of mines and other remarkable improvements.

One of the most far-reaching developments made possible is the automatic motor-driven centrifugal pump, its satisfactory economic performance being attributable in a large measure to the complete automatic features developed by the author, whereby one or more pumps are automatically primed, started, stopped and protected from damage in a manner that is far superior to manual operation. It offers an ideal pumping unit for handling large quantities of water in underground service, as it occupies little space, has a lower initial cost, a lower maintenance cost and eliminates labor operating costs. In the opinion of many mine managers, it is the logical pumping unit for mining service.

The present article describes a complete automatic mine pumping plant consisting of three motor-driven six-stage centrifugal pumps, each driven by a 500-hp. motor having a capacity of 2,500 gallons against a T.D.H. of 600 ft., for handling 2,300 g.p.m. in dry seasons and 7,000 g.p.m. in wet seasons. A description of the principal features and their operations follow:

PRIMING EQUIPMENT

A centrifugal pump will not pump water unless it is first primed or filled with water. Any type of vacuum pump can be used for priming centrifugal pumps, although the dry-air type of pump appears best adapted for mining

*Presented to Fifth Annual Convention, Practical Operating Men Cincinnati, Ohio, May 8, 1928.

† Power Engineer, Philadelphia & Reading Coal & Iron Co.

conditions, as it is not affected by corrosion from acid mine water. At this installation each pump is equipped with a 50-cu. ft. dry-air vacuum pump driven by a 5-hp. squirrel-cage motor, the control being an enclosed magnetic switch with thermal overload protection.

Vacuum Breaker

An integral part of the vacuum pump is the automatic vacuum breaker, a large metal float chamber mounted above the main pump and piped to the priming pump and priming valves. The priming pump exhausts the air out of the pump casing and suction piping, the water entering the float chamber raising the float, carrying with it a check valve and air valve attached to the float arm. The amount of air entering the float chamber through the air valve is about equal to the capacity of the vacuum pump, and the vacuum maintained is the difference in elevation between the water in the sump and the vacuum breaker. The pump being now primed, remains primed as long as the vacuum pump runs. As soon as the main pump starts, pressure forces more water into the float chamber, raising the float higher, seating the check valve, thus checking the flow of water.

The raising of the float performs the following four functions: (1) A switch is closed when the priming is completed which energizes the main control and starts the pump.

(2) A valve is closed, thus preventing water from being carried over into the vacuum pump during the priming period.

(3) An air valve is opened, admitting air to the float chamber, breaking the vacuum and draining the float chamber.

(4) A drain opens and is so proportioned that a period of 15 seconds elapses before the switch opens, thus holding the switch in a closed position long enough to permit the pump to accelerate to full speed and close the pressure regulator.

Priming Valves

Automatic priming valves are used to shut off the water flow to the vacuum breaker when the main pump starts. In stations where the main pump, priming pump and control are a unit, spring actuated valves are used which materially simplify the wiring. However, when two or more pumps are primed from one priming pump, solenoid valves must be used to control the sequence of pump operations. These priming valves are piped to the vacuum breaker.

Pressure Regulator

The heart of the pump protection is the pressure regulator, a device arranged to open or close an electrical circuit upon change in pressure. Its switch is open when at zero pressure, and closed when a predetermined pressure is reached. The inherent characteristic of a multi-stage centrifugal pump is such that when it loses its water through air leakage, it will maintain pressure in its several stages, except the first stage, although no water is flowing, and if the operation is continued, will result in considerable damage to the pump. Any change from a normal operating condition is immediately reflected in a change of pressure on the first stage. Therefore, the pressure regulator must be connected to the discharge side of the first stage where it is most responsive to pressure changes. If the pump fails to deliver water when starting, due to being air bound, there will not be sufficient pressure to make the regulator function. If the pump loses its water from air leaks in the suction line or packing glands, or should a break occur in the column line, the discharge pressure will drop, causing the pressure regulator switch to open and shut down the pump.

Vacuum Regulator

The vacuum regulator is a device to open or close an electrical circuit upon change in vacuum and is connected to the suction line. Its function is to shut down the pump when the vacuum rises due to a blockage in the suction line or strainer.

Supervisory System

These automatic pumping plants receive one inspection during the eight-hour working shift and run through the idle hours without attention. In order to visualize what the water conditions are, and what pumps are operating, or the relation between pumps operating and the water in the sump, and to signal any trouble that might occur, an indicator and signal system was developed that could be located in an outside substation where an attendant is on duty constantly. It consists of a position indicator controller operated by a float in the pump room, and electrically connected by a multiple conductor cable to an indicating meter and supervisory lamps on a panel outside, giving the following information:

Red lights indicate cycle of priming.

Green lights indicate cycle of main pump operations.

Meter indicates exact level of water in the sump at all times.

An electrical gong signals an alarm when any of the following conditions exist:

Water approaching a dangerously high point.

Failure of any of the priming pumps.

Failure of any of the main pumps to prime.

Failure of any of the main pumps to start.

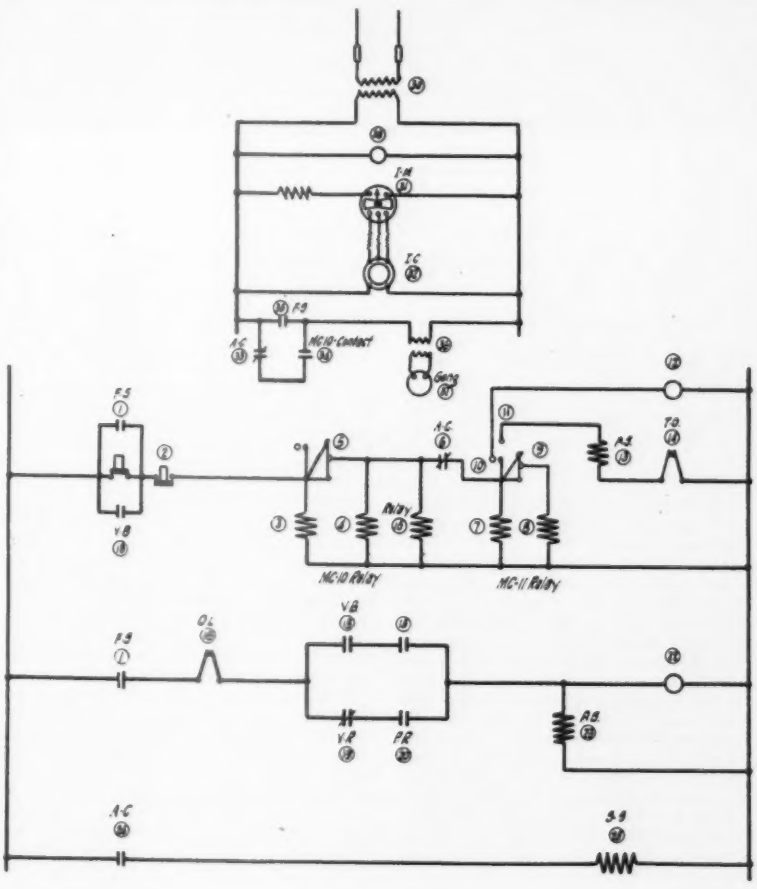
The stoppage of one or more pumps due to trouble.

This information enables the man on duty outside to notify the proper official of any trouble with minimum delay.

Control Circuits

Referring to diagram of control circuits shown in the diagram.

When the water rises to a predeter-



CONTROL CIRCUITS FOR AUTOMATIC PUMP

View of supervisory signal board in substation outside

View of pump house, showing pumps and controls

mined height in the sump, the float switch closes contact (1) energizing the winding circuits (3) and (4) of MC 10 relay, starting the timing action. The closed contact (5) energizes relay (15) closing contacts (15) and through relay (6) energizes the windings of MC 11 relay starting the timing action, and also closing contacts (10) completing circuit for lighting red lamp (12), indicating in the outside substation that priming pump is being placed into operation.

MC 11 relay being timed for 45 seconds, closes contacts (11), completes the circuit for the priming motor starter winding (13) and T.O. contacts, starting the priming pump.

When the pump is primed, the vacuum breaker switch closes contacts (18) completing circuit through contacts (15) for lighting green lamps (22), indicating in outside substation that the centrifugal pump is being put into operation, at the same time completing circuit through (23) primary switch of main pump control, opening (6) de-energizing MC 11 relay, opening switch (13) shutting down the priming pump equipment, and putting out the red light, at the same time closing relay (24) providing a circuit for the secondary control switches bringing the pump up to speed under time-limit acceleration. When the last secondary switch closes, contact (33) opens the alarm circuit. As soon as the pump starts, pressure builds up closing P.R. (20), providing a by-pass holding circuit for (23) when (18) and (21) opens.

MC 10 relay, being timed for 10 minutes, opens contact (5) and relay (15), at the same time closing (34) in the alarm circuit.

Should the priming pump or main pump fail in their operations, (33) would be closed and a circuit established for the signal transformer (36) and the alarm (37) would be sounded; if any of the protective devices, such as the overload (14) or (16), P.R. (20), V.R. (19), or any device other than F.S. (1) should open, the alarm would be given.

Should the water entering the mine exceed the capacity of the pumping plant and rise above the danger point, a separate shunt float switch closes (35) giving the alarm. This float switch also operates an induction controller which is electrically connected to an indicating meter (31) in outside station.

Should the vacuum breaker fail to drain, or the float stick and (18) would not open when the priming pump shut down, the MC 10 relay would remain energized even though F.S. (1) opened. Relay (15) would be de-energized and open, thus preventing the pump from being started without being primed, and would ring the alarm.

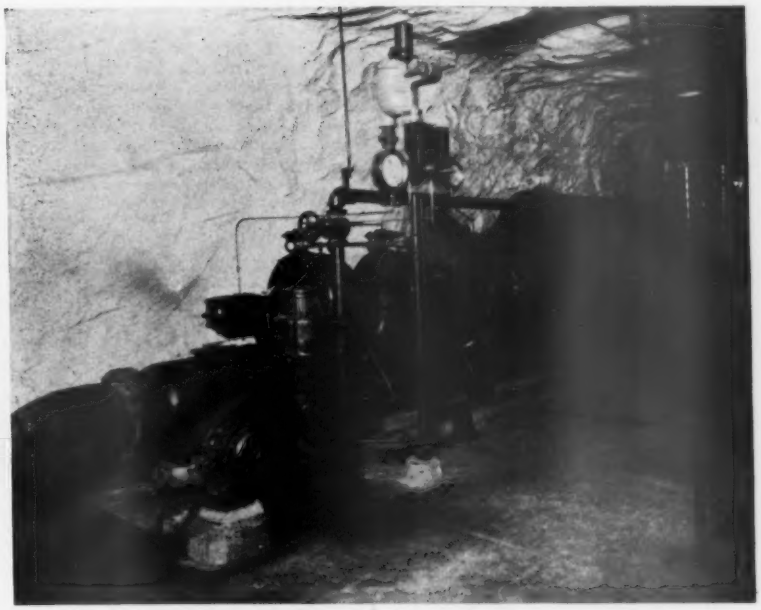
Experience has shown that it is possible to prime a centrifugal pump having considerable air leakage; however, it sometimes happens that, as soon as the pump starts revolving, the water separates from the air and prevents the impeller from delivering water with sufficient pressure to close the pressure regulator; and as soon as the vacuum breaker drains, the pump will shut down and immediately start again, sometimes before coming to rest. It is essential that the pump comes to rest before restarting, and to accomplish this a time limit MC 11 relay is employed to lock out the priming equipment for one minute preceding every start made.

Should any condition arise that the pump would not start properly, it would start and stop repeatedly and cause considerable damage. As it is essential to prevent these repeated starts and stops, a second time limit relay MC 10 is used, timed about 10 minutes, which will allow the pump to make several starts. If it fails to get under way in the time allowed by the relay, the pump will shut down and ring the alarm.

Each centrifugal pump has its own priming pump, with all priming piping interconnected, thus providing emergency priming in case of failure to any one unit. This arrangement avoids complications in wiring and other devices and insures continuity of service by having available stand-by priming capacity. The additional cost of primer is a small percentage of the total investment and is fully warranted.

Operation

In a three-pump installation, the float switches are set so that there is about two feet difference in elevation. Assuming all pumps idle, the water rises in the sump, closing No. 1 float switch, placing No. 1 pump into operation. If the water continues rising, No. 2 float switch places No. 2 pump into operation. If the water still continues rising, No. 3 float switch closes, placing No. 3 pump into operation. Should No. 1 pump fail to start, No. 2 and No. 3 pumps are not affected. In fact, the failure of any one of the three pumps has no effect on the operation of the other pumps. If power fails when all three pumps are running, the units will come back into operation when power is restored. As the water recedes, the reverse operation takes place. No. 3 pump shuts down first, then No. 2 and No. 1 in their re-



A close-up view of one of the pumps, showing the automatic features

spective order as the water lowers in the sump.

The author believes in designing each centrifugal pump with all its accessories and control as a complete independent plant, enabling the average mine electrician to make intelligent inspections, adjustments, and repairs without the assistance of a trained electrician. This arrangement eliminates unnecessary complications in an effort to clear the atmosphere of any mystery surrounding the installation.

These automatic centrifugal pumping plants are replacing water hoisting shafts and steam pumping plants.

In many cases the water shaft comprises an independent four-compartment shaft in which steel tanks, having a capacity of 2,400 gallons, self-filling at the bottom of the shaft and self-dumping at the surface, are hoisted by 45 x 60 double steam engines direct connected to 18 ft. diameter drums and designed to operate on steam pressures varying from 60 lb. to 100 lb., having a rope speed of 2,000 f.p.m., developing 1,500 to 2,000 hp. during the hoisting cycle. Obviously the steam consumption is high, requiring large boiler plants with their heavy operating and maintenance costs.

These hoisting plants require three hoisting engineers every 24-hour day during normal periods, and as high as six engineers with two oilers during high-water periods. Owing to the high rope speeds in these shafts, maintenance on timber work and guides is expensive and renewal cost of ropes is high.

Where water shafts are not permissible, large steam pumping plants are installed, consisting of 21 and 36 x 18 x 48 pumping units designed to operate at from 80 lb. to 100 lb. steam pressure. These pumps are equipped with low-level jet condensers using mine water for condensing. The action of the acidulous mine water on the condenser structure is very severe, making it difficult to maintain a reasonable vacuum for any length of time.

Steam for operating these pumps is taken underground either by bore hole, shaft, or slope. Steam lines are very objectionable in shafts or slopes because of the damage done to inside workings from the heat, and maintenance cost is high. The steam pumps are also extravagant steam users, requiring large boiler plants with their inherent high operating costs. The pumping plants also require three pumpmen every 24-hour shift.

The automatic electric pump eliminates all the objectionable underground features and lowers the operating costs in a remarkable manner, as there are many avenues of costs involved in steam operated underground machinery which are not apparent until the complete steam plant is shut down.

The additional cost to install these automatic features is about 8 per cent more than the cost of a non-automatic plant.

A recent survey shows that there are now over 150 automatic plants in successful operation in the anthracite field without pump runners, representing $500,000 annual savings in labor costs alone; including items of maintenance and supplies the savings will run well over $1,000,000 annually, and many more plants are under construction at the present time.

The remarkable economic showing made by the plants in operation has created much enthusiasm for automatic operation of mine machinery. It is a certain source of profits that appeal to the mine manager under present conditions of the industry.

***E. B. WAGNER**, Lehigh Valley Coal* Co., discussed Mr. Jenning's paper, saying as follows:

"I can take advantage of Mr. Jennings' absence and say that, as far as we know, he is the first mine operator to get the idea of automatic pump control. About 1920, after seeing the pump men sit around the pump houses for 90 percent of the time, and occasionally throw a switch to start or stop the motor, he conceived the idea that that job could be done with automatic equipment, and in conjunction with one of the pump manufacturers and one of the electrical manufacturers, he assembled the necessary devices and relays together to control the pump automatically. Since that time the installation of these devices have been very rapid, particularly in the anthracite field. I think there we have a water condition that the men in the bituminous field are not up against. It is true that they have problems in ventilation, and I understand that fan motors of 200 and 300 hp. are not uncommon, whereas with us our ventilating problems are comparatively simple, but we more than make up on the pump end.

"In our company we made our first installation about February, 1924, and that has been in successful operation ever since. To date we have a total of 33 units totalizing 38,000 gallons per minute and representing a combined motor capacity of 6,000 hp.

"One of the savings that is made by the automatic control of centrifugal pumps is due to the ease with which several units can be installed. In the anthracite field we very often have to pump from several levels, and with the manual control, in order to save labor, the water is dropped by means of bore holes or down the shaft to the lowest level, where a large central pumping plant is installed. With the automatic control, and the absence of pump men, it is perfectly feasible to install a pumping plant at each level and relay the water to the surface.

"There is quite a difference of opinion at the present time regarding the use of squirrel-cage or slip-ring motors for driving the pumps. Our company has had considerable success with the squirrel-cage motor, and we have several installations of motors of 550 hp. which are starting up and getting on the line very successfully with very small disturbance.

"We have found that the starting disturbance can be very much minimized by a careful adjustment of the accelerating relay on the motor starter. If the column line is of an appreciable length, say 600 or 700 ft., we find that it takes some time after the centrifugal pump is up to speed to accelerate the water in the column. If we set our accelerating relay on the starter at such a point that it will bring in the running contactor soon enough after the pump is up to full speed and before the water in the column is accelerated, then the pump is operating for that period against the shut-off pressure and the horsepower required is very much lower than the horsepower when the pump is delivering its normal capacity.

"The M.C.-11 relay mentioned in Mr. Jennings' paper has proved very satisfactory on the automatic control, and also as the accelerating relay on the motor starters. This is a mechanical timing device, and it is possible to adjust the time very closely. The relay also has a low cost, which is another advantage.

"The spring-operated priming valve mentioned by Mr. Jennings serves a two-fold purpose, in cutting off the pump from the priming system after it is started, and also, due to the fact that it requires a positive pressure to close the valve, the vacuum in the priming system is effectively broken, allowing a quick drain, which is necessary for a successful re-start in case that is required.

"We have found that a diaphragm-type pressure regulator, having a large

diaphragm, is preferable to one with a smaller diaphragm, as it is more sensitive to small changes in pressure. In some installations, particularly in those where the suction lift is of a nature of 15 or 20 ft., very little pressure will be developed in the first stage of the pump, most of it being required to maintain water in the suction pipe. Under these conditions a pressure regulator with a small diaphragm is hardly sensitive enough to differentiate between the slight positive pressure which is being obtained with normal operation of the pump and zero pressure, which is obtained when the pump loses its water. For that reason we are using now almost exclusively pressure regulators with a large diaphragm.

"Mr. Jennings mentions a very complete supervisory system to check up the operation of this pumping plant; and while that is very nice, if it is possible to install the same, very few of the installations are so favorably situated that such a supervisory system can be used, except at considerable expense. We have tried to make use of devices that would be installed for the operation of the pump to give us supervisory control over the operation.

"To illustrate, there is usually an ammeter on the feeder line which supplies the pump, or pumps, and by marking the scale of the ammeter at the current that one pump would take, and with two pumps in operation, the attendant, if there is one in this sub-station, can easily tell whether the pumps are running or not.

"A great many of our installations are started by means of a timing clock. In other words, we try to keep the pumps off peak, the timing clock closing the control circuit at the proper time, and if the water in the sump is sufficiently high they will start with the float switch. If the operator, or the fire boss, finds that the pumps have not started within this time, he makes the necessary arrangements for an inspection.

"We are not particularly interested in whether the pump failed to prime, or whether the over-load relay tripped out, or some other device prevented the pump from starting. We can find that out after we get down to the pump house. The main thing to know at the outset is whether or not the pump is delivering water at the time that it is supposed to start.

"There are several types of service recorders on the market at the present time which are very low in cost. These consist of a waxed chart driven by a clock, and stylus for making a mark upon this chart. They are both mechanically and electrically operated.

"The mechanical recorder can be attached to some moving part on the control system and will indicate the time at which the pump starts and the length of time it is in service by tipping of the recorder. The electrical recorder can be connected somewhere in the supply or control system to the pump, and the device itself put in the fire-boss shanty, or some other location where it can be readily inspected by the proper party.

"In a number of our installations the pumps may be located at such a point that it is not practical to run a supervisory circuit back from the pump house. But the discharge bore hole is possibly at a point which is accessible to either the fire-boss shanty or some other point. If these conditions exist, we have put a flap over the top of the bore hole, which is raised when the water starts to discharge and that closes a circuit which gives us the proper indication that the pump has started.

"The automatic control, at the present time, is in its development stage, and it would be very nice if the users could come to some agreement on what they want the automatic device to do. This would result in standardization of parts and allow the various manufacturers to make a quantity production materially decreasing the cost of the equipment.

"Each installation has its own peculiarities, but there are certain standard steps which have to be gone through at each installation, and if a standard equipment could be developed to perform the several standard steps that are required in starting, then any special requirements that the particular installation might require could be added as an extra.

"Another point to remember in automatic control, which so many mine foremen do not appreciate, is the fact that the automatic part is only on the starting and stopping and has no connection at all with the maintenance of the equipment. It is necessary that the maintenance be done by some person, so that an occasional inspection is necessary.

"In connection with the automatic substation, our company has about 25 substations in service, 12 of which are fully automatic; the other 13 have automatic re-closing circuit breakers on the d. c. side and might be termed semi-automatic, because the a. c. switch very rarely trips out unless there is a serious overload or a short circuit in the station.

"Our experience with automatic equipment has been very satisfactory, and, in fact, we have had less trouble with our automatic equipment than we have with the manual control sub-stations.

"It seems that no matter how often the operator starts the motor just exactly like he did at previous times, yet, somehow or other, the auto transformers are occasionally burned out.

"In the first automatic sub-stations it was thought necessary to provide against any possible contingency that might happen to the station. Experience has demonstrated that a great many of these contingencies are so unlikely to happen that it is not necessary to protect against them. As a consequence the automatic equipment has been very much simplified.

"One of the points to be observed in the design of the automatic equipment is that of auxiliary contacts. The successful operation of the various units depends on the functioning of these auxiliary contacts, and they should be of such a design that they will not fail to operate in case they get a little dirty or something of that sort. If the contact is of such a nature that it needs a daily polishing up to operate, the chances are that you will have trouble with the operation of the equipment, because unless your maintenance organization is very good it won't be able to get that attention."

SAFETY EQUIPMENT

(*Continued from page* 517)

mean that all his recommendations be carried out immediately, but we should work steadily in that direction and ultimately we shall reach the goal.

"From statistics quoted by Harrington, one might assume that little progress is being made in the reduction of accidents in mines. The reason is we are introducing so many new hazards these days that the work of eliminating the old ones is just about keeping pace with the hazards being introduced. So we will either have to curtail the introduction of hazards or speed up in our protection.

"We may also think that he is laying too much stress upon the hazards of gas and dust explosions, particularly the hazard from permitting the accumulation of gas anywhere any time in a coal mine. Many of us who take part in the recovery work after explosions and see the mangled bodies and the terrific property damage may be apt to emphasize these hazards beyond the weight statisticians would give them when comparing the total fatalities from these causes with some other causes, such as falls of roof, for, after all, the explosion hazard has only accounted for 12 percent of all the fatalities in coal mines in the United States during the 10-year period preceding and including 1926, although in 1924 explosions accounted for 22 percent of the fatalities. However, this 12 percent hazard is given so much publicity by the press throughout the country that the general public assumes it is the chief hazard in coal mining.

"The gas accumulation problem is largely one of ventilation, which is emphasized in the paper by Mr. Maize which is to follow. You can take the most gaseous mine in the world and force enough air into it and properly distribute the air so that it will be almost impossible to have an accumulation or to detect gas with a safety lamp, as long as the ventilating system is working properly; but there may be some weak points in the ventilating system, particularly where the human element is depended upon for control. If this should fail, only for a few minutes, causing an interruption in the ventilation in some section of the mine a very rapid accumulation of gas would be the result and an explosion would follow if there was present any source of ignition.

"This hazard should be stressed, as Mr. Harrington has stressed it—more so now and in the future than has been done in the past—because it is possible for one of these explosions to take a toll of perhaps 1,500 lives, as the tendency is now in the direction of larger mines and connecting groups of mines underground. There are several such mines in this country at present, where as many as 1,000, or more, men are in connected underground workings. You can appreciate what it would mean to have a widespread explosion in a mine of this character. It is essential that every effort be made to prevent the propagation of an explosion by the use of rock dust; and where the rock-dusting method is efficiently employed in these large mines the ventilation should be just as carefully watched, to prevent any accumulation of gas, as the ignition of a large accumulation of gas, without any further propagation of dust, might generate enough carbon monoxide gas that could be carried, through a disarrangement of the ventilation, into sections of the mine not affected by the explosion and asphyxiate a large group of men."

SUPPLYING POWER *through* AUTOMATIC SUB-STATIONS*

By W. C. SHUNK †

Equipment Sufficiently Standardized To Insure Serviceability For Period Of Fifteen To Twenty Years—An Advantage Is That Of Economic Local Installation And Operation Underground—Saving In Labor Costs For Full Automatic Station Pays For Initial Cost In Twelve-Month Period—Economically And Spontaneously Cares For Peak Loads And Depressions

ONE of the pioneers in the electrical industry demonstrated the realization of its convictions, by putting into operation the first nonattended synchronous converter substation about thirteen years ago. While it is true, in this particular instance, that the actual control for starting up and shutting down, without any signal or control wires other than the main leads, as well as the load regulation, was manipulated from another station a mile away, nevertheless this "Automatic Station," as we know it today, was left to its own devices, and it functioned: — without an attendant — and is still so doing with several similar ones, supplying energy to the power network of one of our larger cities.

W. C. Shunk

In the meantime, with apparently considerable research and development ingenuity on the part of our foremost electrical manufacturers, there has been definitely placed at at our disposal in the mining and other industries, "automatic switching equipment," by use of which, in connection with the standard synchronous converter or motor generator set, the complete "Automatic Substation," is no longer academic, but has, in a true sense, become a reality. Substantiation of this realization, aside from the comparatively long experience with street railway applications, may be had from the number of equipments produced and sold by the leading manufacturers to the coal mining industry alone. For the year 1927, there were 93 automatic equipments placed in this industry, representing a capacity of approximately 25,000 kw., or about 33 percent of the total number of equipments sold, including those for manual operation. As of April 1st, 1928, there was an aggregate of 819 equipments in service in the industry, totaling about 235,000 kw., or nearly 300,000 hp.

Recognition of the fundamental merits now inherent in the best types and designs of various classes of mining equipment, has been more or less pronounced recently in the selection and purchase thereof by representative concerns in the industry. With the exacting circumstances under which coal is now being produced, as regards production cost and quality, application, to the utmost degree, of modern methods and appliances, is, seemingly, and without choice, becoming an essential economic necessity; consequently, producing companies are losing little time in taking advantage of aids to efficiency.

Quite a number of companies which have been expending large amounts annually for improvements and additions for better productive facilities, are not overlooking the economies afforded by mechanization betterments, and by thoroughly surveying and improving their electrical power generating, converting, and transmission equipment. For many years, our industry, although not alone, did not comprehend the importance of normal voltage conditions for equipment operation, particularly on haulageways of secondary consequence, and at the working faces. It was not uncommon to find voltage drops from 20 to 50 percent, involving loads of 150 to 500 kw. in many mines. Such drops in potential represent energy losses in direct proportion to the degree of voltage drop, and slowing down proportionately the operating speed of all equipment connected with the circuit. Likewise, it is, as a rule, observed that the greater portion of labor, working with and dependent upon equipment thus affected, are prone, psychologically, to sympathize with the prevailing environment, and resort to a relative decrease in productive efficiency. It may correctly be said that, as the power lags from its normal strength or voltage, so does the action of labor. There seems to be an affinity in this respect which, evidently, can not be counteracted. Electrical equipment in locomotives, cutting machines, pumps, and other apparatus, is subject to much higher maintenance cost because of insufficient voltage at its terminals. Expensive replacement of windings is prevalent with such conditions. These machines, similar in nature to the mine mule, will not produce effectively with normal forage requirements reduced 20 to 50 percent.

Depending upon the number of items to which the varied cost classifications are segregated, there appears on the cost statement of the average colliery a limited number of items pertaining to the cost of power when it is purchased. But whether it be purchased, or locally generated, the figures opposite these items strike one at a glance as being rather insignificant, when compared to the major items of labor, supplies, and the total unit cost figure. As power losses truly deal with the cost statement, a fairly comprehensive analysis of conditions resulting from a power or energy loss of, viz, 15 to 30 percent, will indicate that this loss is surely reflected in many labor and supply items, the aggregate of which will be found, in many instances, to be near the equivalent of the actual cost to purchase or generate the power. The management or supervisory organization which does not take seriously into account the fact that supplying normal power to equipment designed for a certain voltage, will, as long as such adverse conditions exist, continue to contribute in expenditures, which if anticipated, corrected and conserved, can be appropriated most advantageously to the fund which should be available for the ever-increasing need of progressive improvements. In the coal mining industry today, considering the many economic problems with which it is confronted, there is, and rightly should be, an earnest effort and tendency toward the greatest possible degree of complete electrification and mechanization for the extraction of the product at the working faces, and its transportation to the units which carry it by rail and water to the points of consumption.

By reason of the apparent progressiveness in effecting economies, the management and engineering personnel of representative mining companies are rapidly coming to the realization of inculcating electrical energy, with the most modern and dependable equipment, into almost every phase of mining, and the various work jobs involved in the production of coal. Of the various phases involved, power and transportation are generally conceded to be of nowise lesser importance in the category; as the mine produces, and the workings extend farther and farther underground from the productive entrance, commensurate with these annual extensions do the problems and difficulties arise, and often multiply, from the standpoint of efficiency as regards power and transportation. As the process of annual development increases its scope, the length of haulage is proportionately greater; consequently, the cost of power and transportation is consistently added. Therefore, it is essential that ways and means be devised and provided at certain intervals to prevent these items of cost gradually mounting out of proportion. With the central station and purchased power arrangement, the energy supplied for transportation and other purposes underground usually requires conversion from alternating to direct current, and for this service the equipment involved is either the motor generator set or the synchronous converter, in unit capacities from 150 to 500 kw., used singly, or in multiple, as best suited for the application. The installation of these units, with their respective switchboards or switching equipment, constitutes the sub-station. These stations are subdivided into three different

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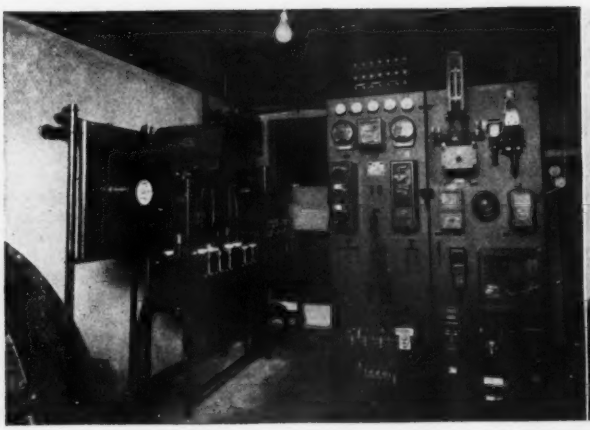
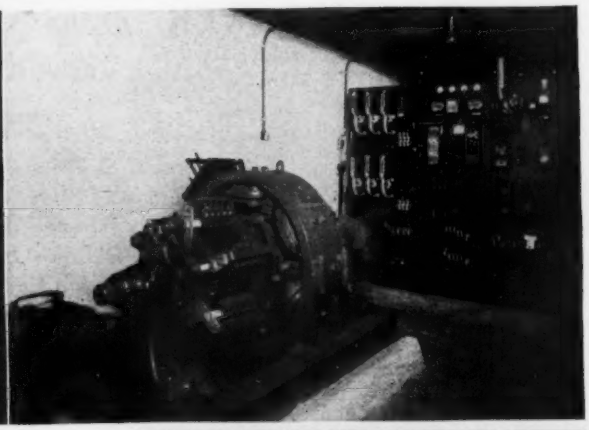
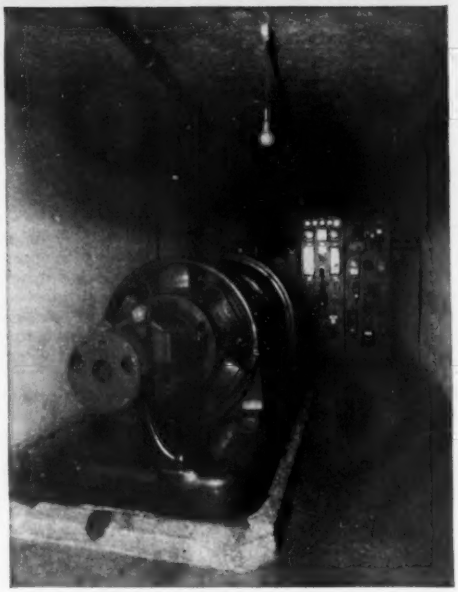
† General Manager, Stonega Coke and Coal Co.







Above, left—Close-up of 2,-300-volt starting assembly (left) and automatic switching equipment for 200 k. w. generator set in underground substation

Above, right—150-k. w. pedestal type synchronous converter with full automatic switching equipment in underground substation

Right—200 k. w. generator set with full automatic switching equipment in underground station

types, and are generally classified as manually operated, semi-automatic, and full automatic. Each type, it is believed, has its peculiar economic application, depending, as a rule, on whether its location be convenient to, or remote from, an employe engaged in other duties who can be assigned the additional duties required for attendance of the station. In the selection of switching equipment, with reference to the types obtainable, it is often readily recognizable that in the conclusion the manual or semi-automatic equipment is often favored, apparently from a traditional view, and the matter of having too greatly weighed the economies effected by adding the attendance duties to an available employe, and, without due deliberation in evolving the benefits to be derived in the return on investment, as well as the inherent meritorious characteristics of the automatic equipment from the standpoint of operation continuity and its protection to the machine.

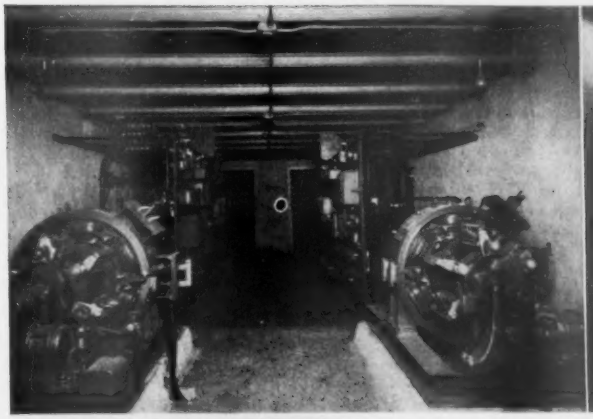
In effecting means for combating the gradual upward trend of power cost, it will be readily discerned from statistics given herein that already a comparatively large number of operating companies are supplying their power requirements through automatic sub-stations, the practice of which affords economies from many operating angles, notwithstanding the labor cost for the attendant necessary for the non-automatic station.

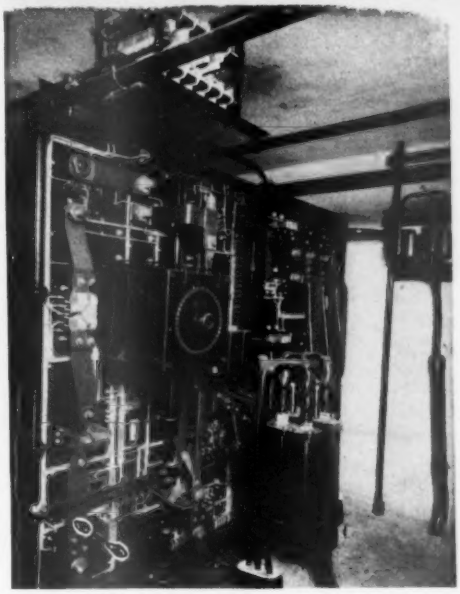
In the conversion of power, and directing it through the type of automatic station as generally used for mining service, there is no added complexity to the arrangement as applies to the manually operated switchboard, in so far as the a. c. incoming, and d. c. outgoing, power circuits are concerned. The installation cost, therefore, both for labor and wiring material for the power and auxiliary circuits within the station, is but slightly more for the automatic equipment.

For station units, of either the motor generator sets or synchronous converters of comparative capacities requiring buildings on the surface or enclosures underground, the automatic equipment does not require additional floor space over the non-automatic; hence this item of installation cost is practically identical in both cases. Likewise, no special or supplementary apparatus is required for the external circuits in connection with the automatic equipment, either adjacent to, or remote from, the station, provided a control circuit is not desired for the purpose of remote starting.

The additional cost of the full automatic station complete over the non-automatic, lies almost wholly in the accessory devices and automatic switches which primarily function to replace the human element, and, secondarily, for more complete protection against damage electrically and mechanically to the machine it controls. Careful analysis, however, of the specifications and the merit of the additional apparatus involved, will, in most cases, convincingly justify the additional expenditure. Depending on the nature of application, the difference in the investment is compensated for by the saving in attendance labor cost within 12 to 18 months. With all equations to be considered in current vogue, the prospective purchaser of equipment must, of necessity, be motivated by a different psychology than that prevailing even five years ago; therefore, with a little exacting analysis from the viewpoint of economy, it will doubtless be found that there really exist but few substantial arguments against the selection of automatic equipment, regardless of the favorable factors applicable to the non-automatic, and the price differential applying.

With the type of station being considered herein, it has been demonstrated by several years of experience and successful operation that the switching equipment proper is much more rugged, reliable, and serviceable, than the knife switches and protective devices furnished with the hand operated switchboard; therefore, its suitability is better in conformity to the severe characteristics of the average mine load, which is extreme in variations due to the starting of heavy haulage trips and negotiating variable and heavy grades, resulting in momentary marked peaks and low valleys, representative of the mine load curve. Not only are the functions of starting and stopping performed automatically by this type of station, but emphasis should be placed and due consideration given the matter of complete protection afforded the machine and equipment in service. It is quite true that only those fairly familiar with the characteristics and peculiarities of station equipment, really appreciate the significance of added protection given the machine by the use of the various relay and other protective devices furnished as standard with the automatic switch-





Upper, left—Installation of two 150 k. w. synchronous conveyers with full automatic switching equipment in underground substation

Upper, right—Rear view showing transformers sitting as shown in rear of view to left

NOTE—*Plan shows wiring arrangement for removal of transformers from rear; also note unique arrangement of setting converter, switchboard and transformers in line, facilitating the installation of two units in a very narrow space*

Left—Rear view showing wiring arrangement of automatic switching equipment for 150 k. w. synchronous converter in underground substation

ing equipment. The following represents the greater number, and briefly outlines the nature of the protection provided by these devices:

1. Low voltage, a. c. and d. c.
2. Overload, a. c. and d. c.
3. Overheating of machine windings.
4. Overheating of machine bearings.
5. Failure to complete the starting sequence.
6. D. c. reverse polarity of machine.
7. D. c. reverse power, if station is operating in multiple with another.
8. Loss of machine excitation.
9. Phase unbalance.
10. Phase failure.
11. Overspeed of machine.
12. Underspeed of machine.
13. Prevents the reclosing of circuit breaker on short circuit or excessive overload.

With the protective apparatus as outlined, in connection with and safeguarding a machine, it is entirely reasonable to assume that practically all of the serious and expensive damage, with the attending delays, heretofore experienced with the non-automatic station, will be almost entirely eliminated. There are also a vast number of short interval interruptions common to mining practice, resulting from short circuits and other causes, which are not effectively taken care of by the attendant of the manually operated station. Summarize these delays for the period of a year, and it will probably be concurred in that the average mine loses the equivalent of one week to 10 days' operating time. Experience bears out the fact that "Automatic Switching," without question, reduces to the minimum delays of this nature.

A time saving factor must also be credited the "Automatic" for the starting cycle. It is found in this respect that the automatic equipment will, from a standstill, start the machine, accelerate to normal speed, energize the generator with correct polarity, and induce energy to the mine circuits within 10 seconds from the instant of actuating the master element; whereas, with the manually operated equipment, the trained attendant requires, on the average, 58 seconds to perform the same duty, provided the machine polarity is correct, and, quite often, double the time if polarity must be corrected by hand. Obviously, another time delay factor for consideration, and one which apparently can not be corrected in connection with hand operated equipment, is the costly and annoying characteristic of the "human" actuating auxiliary in its susceptibility to drowsiness, yawning and stretching. Thousands of tons of coal are now in its natural state underground, which should have been produced for consumption had the time delay relay functioned to really energize and actuate the human operating solenoid, bell cranks, and reciprocating mechanism.

Other advantages of the automatic equipment lie in its adaptability for installation in smaller segregated units, rather than one large, or a group of smaller manually operated units at one or more locations convenient for low attendance costs. With the former, better distribution of voltage conditions prevails for equipment operation commensurate with the minimum of power losses and copper conductors required for the load; while with the latter arrangement of units, it is too often found that because of the apparent cost of adequate feeder copper, the general tendency in mining is to violate and disregard the Ohm's law, and revert to the popular installment payment plan by adding to the monthly power bill and contributing to the loss of production with its attendant cost, and constituting at least one mining sinking fund which is forever sunk. Generally speaking, in instances where the load demand is 300 kw., or more, at 250 volts d. c., and necessarily distributed over a distance of about 1½ miles along the main feeder of a mine, it will be found that to provide sufficient feeder copper, permitting a reasonably small power loss, the copper cost installed will about equal that required for installing the station equipment at two advantageous locations. An idea of the advantages to be derived by locating stations within their economical load zone may be had by reference to an operating company that, in 1915, replaced five isolated power plants totaling 2,400 kw., and serving six collieries, with substations mostly located underground. This company recovered sufficient feeder copper from the isolated plant arrangement to serve the copper requirement of eight collieries producing about 3,000,000 tons annually for 11 years, without purchasing one pound of feeder conductor.

The automatic equipment readily lends itself to economic installation and operation underground, thereby affording the advantages related in the foregoing, with particular reference to segregated placement at points of load centers, and the possible savings to be had therefrom. Reference is made to a representative installation at a mine in Virginia. At this mine, on the main haulage, the average grade is 3½ percent

against the loaded trips for a distance of 2½ miles. The motive power is 13-ton locomotives, operating in tandem, two of which, with the gathering locomotives and auxiliary equipment, are served by four synchronous converter substations totaling 1,050 kw. Three of these stations, 300 kw. each, are located advantageously along the haulageway, and the fourth station, 150 kw., near the mine entrance, all of which are subjected at intervals to tremendous peak overloads. A. c., 2,300 volts, is transmitted to the underground stations through boreholes from the surface, one 300 ft. and two 600 ft. in depth. The topography of the surface and the cover overlying the coal (averaging 1,100 ft.) necessitates the location of boreholes in ravines; hence, in locating the stations adjacent to the haulageway and d. c. feeders, from 100 to as much as 1,500 ft. of armoured 3-conductor cable is used for the interval between the bottom of the boreholes and the stations. Three single-conductor cables banded separately to steel messengers are used in the boreholes, and these, as well as the armored cable, are insulated for 6,600-volt service as a factor of safety. With this power arrangement, the mine which produces 2,500 tons per day, is supplied throughout with a practically normal d. c. voltage.

Time does not permit narrating other possible interesting matters pertaining to the subject, such as semi-automatic equipment, which is a step from non-automatic toward the full automatic, or a "go-between," so to speak; also operating characteristics of the full automatic, and how they favorably reflect on different phases of mine operation; an outline of inspection and maintenance, both of which are surprisingly low in cost, as well as a fairly concise description of the equipment and its sequence of functioning. It may well be stated in conclusion, that automatic switching equipment, although conspicuously complicated to the layman, does not essentially require a high degree of intelligence and experience for its proper inspection and maintenance. Its reliability has been substantiated by comparatively long experience and hard usage in mining service, and, the average mine electrician-in-charge, with but a reasonable amount of experience, and by reference to the simplified instructions and wiring diagrams furnished by the manufacturer, can familiarize himself sufficiently with the fundamental principles to competently maintain the station equipment.

The prospective purchaser may acquire some consolation in the statement that, unlike the radio and automobile from the viewpoint of obsolescence, this equipment is now surely perfected to the point where at least 15 to 20 years of dependable service should be expected.

It is appropriate here that a word of tribute be paid the intelligence and efforts of the engineering and research personnel of the manufacturers in the development of this humanlike apparatus. Evidently a real engineering achievement is represented electrically, and, in its present status of perfection, perhaps only one needed correction is in evidence; that is to say—the designation "Automatic" should perhaps be superseded by the more expressive title, "Spontaneous."

***F. L. STONE**, General Electric Co.*, discussed Mr. Shunk's paper, as follows:

"I feel very much flattered indeed at being asked to discuss the very complete and instructive papers you have just heard. I think the management very wise to keep the manufacturers in the background and give you operators a chance to discuss fully and without reserve your problems.

"However, I do not know of an industry in which the manufacturers have done more real development and research work than in mining. If any of you will take the time to look over any modern mine, following the product from the face to the railroad car, then look over the auxiliary equipment, such as fans, pumps, substations, etc., I think you will agree that the manufacturer has contributed quite something beside iron, copper, lumber and concrete at so much per pound.

"As Mr. Jennings has told you, there is probably more intensive pumping in the anthracite field than is to be found in any other mining locality. With this condition existing, it is not surprising to find that the anthracite operators are the pioneers in the development of new and more economical pumping methods. The cost of pumping is such a considerable part of the total mining cost in the anthracite field that any savings effected would amount to large total annual savings in dollars. Mr. Jennings advises that the savings in labor alone from 150 automatic pumping stations amounts to $500,000 or $3,300 per station. I see no reason why the size of the station or the number of pumps involved would change this figure to any great extent.

"I am glad Mr. Jennings referred to the principle of having each pump unit complete in itself. Personally, I strongly favor this idea. The scheme of having one priming pump serve several main pumps seems rather, for obvious reasons, penny wise and pound foolish.

"It may be that some of you fear that because of so many control devices, including float switches, vacuum breakers, relays of various kinds, etc., etc., you would be purchasing a very active source of endless trouble to keep the equipment operating. I believe this to be far from the case, as indicated by the experience of users. I wonder if Mr. Jennings could give us some idea as to the "time out" on any of his pumps due to trouble with the equipment, be it electrical or mechanical. It would seem to me that the question of automatic operation of equipment should interest you all most vitally. In the case of pumps and substations, the problem has been worked out, and, I think, solved, and, as Mr. Jennings and Mr. Shunk have shown you, the savings which have resulted have been out of all proportion to the added investment.

"But how about the other machines? Can you not go much further with automatics? How about fans and compressor stations? Do you still keep a man there with an oil can in one hand and an out-of-date Sunday newspaper supplement in the other, drawing down $5 per day or more for doing practically nothing? Five dollars per day, full time, makes $1,820 per year, or $5,500 for three shifts per year.

"You should, of course, understand that no automatic station will run indefinitely without any attention or inspection. All moving machinery needs some watching. There are still some things which can happen which can not be guarded against by anything but human intelligence.

"Regarding troubles which might develop and shutdowns due to the automatic features, I made inquiry of one of our field men regarding an operation where several full automatic stations were installed, and his reply wire read as follows:

" 'Have discussed your wire with customer's chief engineer today. He advises no interruptions chargeable to automatic substations. Stations have operated continuously since installation with exception of strike periods, and only replacement one relay coil and contacts on starting contactor. Customer just now starting up after shutdown and two days' running shows no trouble. One electrician inspects and maintains four stations besides several pumps, spending two-thirds time on stations. Customer keeps stations unusually clean.'

"The particular substations referred to were installed in 1923, and their performance, while nothing exceptional, illustrates what might be expected in the way of continuity of service. On the other hand, the last sentence in the telegram just read seems to me to be very indicative. I will read this last sentence again, 'Customer keeps stations unusually clean.' Show me an automatic station of any description that is not kept neat and clean, and I will show you a station which almost invariably gives more or less trouble."

***R. J. WENSLEY**, Westinghouse Electric & Manufacturing Co.*, said:

"Mr. Shunk has made a very complete analysis of the automatic substation problem, and I think he is overly modest when he says he can do anything else better, because I don't believe he could do a better job in any other type of equipment than he has done on the automatic. We certainly appreciate his thoroughness in analyzing the automatic problems.

"I would like to emphasize the dependability of full automatic equipment versus partial or semiautomatic. You know it is awfully easy to say, 'We have a man adjacent here in the blower house, or a hoist man, who can give part of his time to the job.' But, if any of you have had experience in trying to get those men to give part of their time to the job, I think you will agree with me that the small extra cost of the full automatic equipment is well justified, because those men whose prime duty is something else will always treat the substation as a secondary duty and let it go in time of stress, just when you need that help most. Many times the small extra cost will save itself on the first interruption, especially where power interruptions are at all frequent.

"The matter of standardization was mentioned as an important point with all big manufacturers. It is just as much so with us as with any other manufacturers of equipment. You know customers have a habit of having their own ideas about things, and in several years of experience in the automatic switching industry I can testify that there is no exception.

"I want to tell you that we have less trouble with our mining customers than all the others in the whole field. The mines will take standard equipment from us much more (*Continued on page* 546)

GENERAL PRINCIPLES *of* DRY CLEANING *of* COAL*

By THOMAS FRASER†

Dry Cleaning Processes Divided Into Three Principal Groups, Hand Separation, Mechanical Slate Pickers And Gravity Separation—Application Of Pneumatic Machines—Special Features Of Air And Water Separation

ALL processes of separating coal from its impurities do so by taking advantage of some difference in physical character of the coal and dirt particles. Dry-cleaning processes may be divided into three principle groups, depending upon the special characteristic difference between coal and slate that forms the basis of the process. These are:

(1) Hand separation which depends upon difference in physical appearance. The elements essential to good preparation by this method are (a) distinguishable difference in color or texture between coal and slate, (b) good light, (c) arrangement of picking tables so as to expose impurities to the best advantage, (d) interested attitude on the part of workmen.

E. A. Holbrook, chairman of the first session on Coal Cleaning

(2) Mechanical slate pickers in which the predominating factor is difference in mechanical friction coefficient of coal and slate. Differences in shape of particles and specific gravity also enter.

In many of these machines the raw material is passed over gravity chutes of some form, and the coal, which has the smaller coefficient of friction, attains greater momentum than the slate; the two groups of particles are thereby separated. Other dry pickers of this classification, such as the Frederick separator, are particularly designed to take out flat pieces. This is a valuable auxiliary separator in plants treating a coal in which the slate runs to flats; a very troublesome form of impurity to handle in gravity separators.

Thomas Fraser

(3) Gravity separation, which depends primarily upon the difference in unit weight of coal and slate. In processes of this classification the raw material to be separated is subjected to the action of flowing currents of some fluid, such as air or water. A separation between heavy material and light material results because light particles are more easily moved by such a stream than are heavy particles. Practically all the widely used wet washing and air-cleaning processes of treating coal make use of this principle in one form or another.

GRAVITY SEPARATION

The separation of particles into groups of like specific gravity by means of currents is commonly called gravity separation. Such methods are widely applied to the treatment of various mineral products, and either air or water or other fluid medium may be used. The fundamental principles of gravity separation are the same whatever minerals are being separated or whatever kind of medium is being used. Hence it is difficult to restrict a discussion of this kind strictly to the dry cleaning of coal. Coal can be cleaned by a gravity process because it is lighter than slate and pyrite—the impurities that contaminate it. The flowing medium may be applied in many different ways, and many different devices are in use for carrying out the process. However the raw material may be handled in the medium, the lighter coal particles will be buoyed up more effectively and carried faster and farther by the current than will the slate particles.

The oldest and simplest example of such a process is the natural running stream, which is constantly sorting and grouping according to size and weight the debris carried along by it. Thus in the swift headwaters, heavy boulders may be carried along to be dropped at the first slackening of the current. In successively lower reaches where the gradient decreases, the stream drops successively lighter classes of particles that it can no longer carry because of decreased velocity. Similar sorting action of the wind may be observed in arid regions. The changing winds and streams are continually shifting and reassorting the broken material carried along by their currents. The development of a gravity separation process consists in making use of the same sorting currents subjected to constant, controlled conditions, so that a certain constant sorting effect is maintained.

Figure 1—Effect of currents on arrangement of coal and slate particles. Shaded pieces are coal, unshaded pieces are slate

To analyze this differential carrying effect of streams, consider the force applied to an individual mineral particle (of cubical or spherical shape for simplicity of calculation). The force exerted by the current impacting against the surface of the particle will be proportional to the area of the cross-section of the particle and to the square of the velocity of the current.

Total force is, therefore, proportional to $D^2 V^2$. Where D is the diameter of particle and V is the velocity of the current. On the other hand, the force required to lift or move the particle is proportional to its weight immersed in the fluid or to its volume and density, which may be expressed as $D^3(S\text{-}S^1)$. Where S is the specific gravity of the particle, S^1 is the specific gravity of the fluid; $(S\text{-}S^1)$ thus expressing the net effective density of the body buoyed up by the fluid. Hence we may express the relation between the carrying force of the current and the maximum particle it will move as follows:

$$D^2 V^2 \propto D^3 (S\text{-}S^1) \text{ or } D^2 V^2 = K D^3 (S\text{-}S^1) \qquad (1)$$

Where K is a constant, that may be determined by experiment.

Solving this equation for V to give us the velocity required to move the particle

$$V^2 = \frac{K D^3 (S\text{-}S^1)}{D^2} = K D (S\text{-}S^1)$$

$$V = \sqrt{K D (S\text{-}S^1)} \text{ or } C \sqrt{D (S\text{-}S^1)} \qquad (2)$$

Replacing $\sqrt{K}$ by the new constant C.

The value of this constant must, of course, be adjusted to suit the units in which V and D are expressed.

The absolute value of this expression is of little moment. The important thing is the relative velocities required to carry the coal particles and the slate particles in a given mixture; for if these velocities are different, this is; if a certain velocity may be maintained such that it will carry away the coal and will not move the slate, then it is theoretically possible to make the desired separation.

Now it is obvious that the size as well as the density has something to do with this. If the coal and the slate are of the same size, then a current that is just sufficient to carry the coal will not move the slate, but if the coal particles are larger than the slate particles, then this may not be the case. At some certain ratio of sizes the big coal particle

* Presented to 5th Annual Convention, Practical Operating Men, Cincinnati, Ohio, May 8, 1928.

† Consulting Engineer.

would require just the same velocity as the small shale particle. Hence, with this difference or a greater difference in size, the separation could not be made. This limiting ratio of sizes can be determined by substituting the specific gravity values of coal and slate in the equation above and making the velocities equal, then solving for D in each case.

$$Vc = C\sqrt{Dc\ (Sc - S^1)}$$

$$Vs = C\sqrt{Ds\ (Ss - S^1)}$$

Subscripts c and s refer to coal and shale particles, respectively. If Vc=Vs then—

$$C\sqrt{Dc\ (Sc - S^1)} = C\sqrt{Ds\ (Ss - S^1)}$$

$$Dc\ (Sc - S^1) = Ds\ (Ss - S^1) \qquad (3)$$

$$\frac{Dc}{Ds} = \frac{(Ss - S^1)}{(Sc - S^1)}$$

This gives the ratio of sizes of light and heavy particles that can just be moved by the same current velocity.

If we take the specific gravity of slate (Ss) to be 2.5 and the specific gravity of coal (Sc) to be 1.3, then this limiting diameter ratio for treatment in water is

$$\frac{Dc}{Ds} = \frac{2.5 - 1}{1.3 - 1} = 5 \qquad (4)$$

and for treatment in air

$$\frac{Dc}{Ds} = \frac{2.5 - .00124}{1.3 - .00124} = 1.92 \qquad (5)$$

The size ratio calculated in this way is called the free settling ratio. It evaluates the difference in the maximum size of coal and slate particles that a given current velocity will carry when the particles are unobstructed and absolutely free to move.

In operating machines where the material is treated in a crowded mass so that the particles interfere with each other, experiment has shown that the actual ratio is greater. There are also other conditions that may be taken advantage of to increase this ratio: (1) heavy particles falling through a fluid accelerate more rapidly at the start than light particles, irrespective of size; (2) large light particles are more difficult to reverse or change in direction of travel than small heavy particles requiring the same carrying velocity. The above ratios, however, show the basis of gravity separation and one of the essential differences between water and air treatment.

Application in Pneumatic Machines

Perhaps the most widely used form of separating current is an upward vertical current, either constant or intermittent, and often accompanied by mechanical agitation of the material under treatment. Consider the accompanying Figure 1 to be a cross-sectional view of a portion of a jig bed or the deeply bedded portion of a pneumatic coal table near the feed end. A current of air or water flows upwardly through the screen bottom in the direction shown by the arrows. In the jig this current is intermittent. A blast of air or water tends to lift the material on the screen. It then has a brief interval in which to fall through quiet air or water or a slow downward current of water. On the pneumatic table the same effect is obtained by the combination of air flow and table deck motion. A steady current of air flows upwardly through the screen but not of sufficient force to lift the material bodily. The reciprocating motion of the table is such as to give the material a small upward throw on each stroke, which loosens up the material and lifts it slightly above the deck. In the short interval following each impulse the particles drop back against the air current. The result in either case is to arrange the particles in separate strata with the heavy slate at the bottom and the coal on top. This comes about by the following cycle:

1. During the upward stroke the coal particles are lifted more easily and consequently farther than the slate particles. Two particles originally together on the screen may be lifted to the relative positions shown in Figure 2. Then the upward force is removed and the particles fall back. The slate particle will fall faster than the coal particle and tend to increase the separation. In a mass of such particles there is much interference with this operation, but the result of sufficient repetition of this cycle of operations is to arrange the mixture in the way shown in Figure 3.

This is the first step carried out in many gravity processes of separation. To complete the separation it remains to remove the two strata separately from the machine without taking particles of the one with the other. A gravity separator is a machine which carries out these two basic operations continuously.

In a jig the products are discharged directly from the stratified position. The upper stratum is generally allowed to overflow one side of the separator, and the lower stratum is drawn off by a gate at or near the screen level. On the pneumatic table these superimposed strata are first spread out into two separate flat zones arranged side by side on the same surface. This is an intermediate step intended to facilitate final discharge. When finally ready to be discharged from the machine, the two strata are in contact along a thin line instead of a broad plane, as in the first arrangement.

This zoning effect is produced primarily by the conveying motion of the deck which moves the slate particles that are in immediate contact with it out from under the lighter upper stratum. At the same time these light coal particles, buoyed up by the air so that it receives much less conveying impulse from the table motion, flow down the transverse slope of the deck. In continuous operation these things all go on at the same time. The shale travels out from under the coal as fast as it collects, so that a continuous layer of shale never actually accumulates on the screen in the stratification zone of a table. However, these steps are the primary elements of the operation.

Coal Characteristics

The foregoing is a very elementary physical explanation of why coal and slate can be separated by controlled currents of air or water. The other side of the picture is presented by the coal itself. In any coal-cleaning operation, the physical characteristics of the coal must be given equal consideration with the principles of operation of the cleaning process.

In order to give mathematical form to the principles upon which gravity separation depends, expressions were derived showing the effect of currents on cubes or spheres of pure coal and pure slate; but the feed to an operating plant does not consist of cubical and spherical particles nor of pure coal and pure slate particles. The coal seam breaks up into an infinite variety of irregular shapes, and supplies in individual particles all degrees of admixture of coal and mineral matter ranging from pure coal on the one extreme through bone, and carbonaceous shale to pure shale and pyrite on the other extreme.

TABLE OF CALCULATED FREE-SETTLING RATIOS

Specific Gravity Coal	Specific Gravity Impurity	Ratio of Sizes Requiring Equal Carrying Velocities In Air	In Water
1.3	2.5	1.92 coal to 1 slate	5 coal to 1 slate
1.3	2.3	1.77 to 1	4.3 to 1
1.3	2.0	1.54 to 1	3.3 to 1
1.3	1.8	1.38 to 1	2.7 to 1
1.3	1.6	1.23 to 1	2.0 to 1
1.3	1.5	1.16 to 1	1.7 to 1
1.3	1.4	1.08 to 1	1.3 to 1

The effect of irregularity in shape is to complicate the effect of carrying currents. In general, pieces with large surface area compared with their volume are most easily moved by a current. Hence where the slate runs largely to flats and elongated pieces and the coal breaks in prismatic and pyramidal shapes, this condition counteracts, in a measure, the selective actions of the current on the coal, and decreases the effective separation ratio.

The effect of bone coal, light carbonaceous shale, and interlaminated particles is to make the separation more difficult and reduce the effective settling ratio. While an air current will separate a pure slate particle from a pure coal particle twice as large, this is not so feasible if the slate is intermixed with coal so that its specific gravity is 1.8 instead of 2.5. The accompanying table gives the theoretical free settling ratios of coal of 1.3 specific gravity and impurities of various specific gravities.

While these free-settling ratios are not exactly equivalent to the effective separation ratios, they show why it is difficult to separate bony and laminated impurities from coal. Particles that are on or near the dividing line in specific gravity between coal and slate—that is, near the specific gravity of separation—are most troublesome. The percentage of this near-gravity material in a raw coal is a good index to the feasibility of cleaning.

A still more important effect of mixed impurities is the great increase in preparation loss for a given improvement in quality, where the improvement is brought about by removal of such mixed material. The ideal operation would clean up the coal by taking out pure mineral matter; but this can not be done in practice. Some combustible matter is always inseparably mixed with the impurities, and to remove the impurities coal must also be removed. Furthermore, this condition is progressive; as lighter classes of impurities are removed to gain additional cleaning effect, the proportions of combustible lost with the

refuse increases. Every operation, therefore, resolves itself into a compromise between the most desirable coal product and an economically feasible rejection in the refuse. Performance of the plant, in this respect, depends primarily upon the nature of the raw coal rather than the principle of operation of the process used.

Special Features of Air and Water Separation

There are certain differences in the characteristics of air and water that necessitate important differences in the commercial application of these principles.

(1) Water is in itself an inert, worthless impurity in coal.

(2) Air is much lighter than water.

(3) Air is much more fluid than water.

Inasmuch as water is an undesirable ingredient in coal, the use of water as a separating medium necessitates a two-stage operation. Firstly, the slate and pyrite are separated from the coal by gravity separation in water. Secondly, the water introduced in the first stage is subsequently removed to complete the cleaning operation. This necessitates the addition of coal drying and water clarifying equipment in wet plants.

The fact that air is much lighter than water limits the separation to a small ratio of sizes. That is, coal and shale particles of nearly the same size may be separated by air, but if the slate particles are much smaller than the coal particles then they will be equally affected by the air current. The reason for this is shown by the settling ratios in water and air, equations 4 and 5. The theoretical limiting ratio for coal and slate in air is here shown to be 1.92. While there are other factors, such as shape of particles, that affect this, a 2 to 1 ratio has been found, in practice, to be about the maximum range of sizes that can be separated well in one operation. Complete accurate screening of the coal into separate-sized products before treatment is, therefore, essential to satisfactory performance of the separators. Application of the penumatic table is limited to dry coal primarily because of the difficulty of screening damp coal rather than by difficulty in handling damp coal on the separators.

While the settling ratios in air are much smaller than in water the settling velocities are higher. Because of the lightness and fluidity of air, the particles move and separate very rapidly. The pneumatic separators have a large capacity for a given size or area of the machine.

The same qualities of air, i. e., its lightness and fluidity, make it more difficult to control the flow of air and maintain the desired distribution of currents in the separator. The design of air ducts and means of controlling the air flow through the deck and coal bed upon it, is one of the most important technical features of a pneumatic table. This is essential to make a good separation, to economize in the amount of air used, and to minimize the amount of dust-laden air ejected into the building or dust-collecting system.

The dust or slime handling equipment constitutes a third important department of the coal-cleaning plant. Whether air or water be used for cleaning, the medium unavoidably picks up and carries away in suspension the very fine particles in the plant feed. To separate this dust from the air or the water, so as to recover the coal and clarify the medium, is the function of the dust handling equipment.

Figure 2—Effect of currents on arrangement of coal and slate particles. Shaded pieces are coal, unshaded pieces are slate

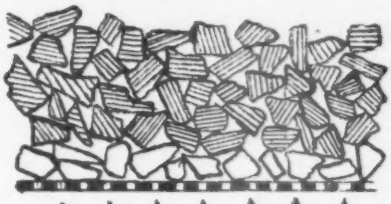


Figure 3—Effect of currents on arrangement of coal and slate particles. Shaded pieces are coal, unshaded pieces are slate

In the various methods commonly used for separating the dust from air or water three general principles are employed:

(1) Reducing the carrying power of the fluid by reducing its velocity. This depends upon the fact that the carrying power of a stream varies as the square of its velocity. This principle is employed in settling tanks, thickeners, and dry-dust collecting chambers.

(2) Utilizing the difference in momentum or resistance to change in direction of travel of air and dust particles. This principle, combined with decrease in velocity, enters into the operation of whirling dust separators.

(3) Filtering of the fluid through a fabric or screen that retains the solid particles. This method is employed both for clarifying water and clarifying air.

In all of these methods of dust handling the important factor that determines the size of equipment needed is the volume of air or water in which the dust is suspended. Hence the dust handling problem is minimized by keeping the air or water consumption per ton of coal handled down as low as possible. This carries the problem back to design and control of currents in the separator.

The general principles of separating coal from slate are similar in wet plants and dry plants. The principal differences are in supplementary operations that differ in method because of the difference in nature of the medium used. These supplementary operations are: In dry plants, (1) screening; (2) dust collection and air purification. In wet plants, (1) washed-coal drying; (2) sludge recovery and water clarification.

***J. R. CAMPBELL**, American Rheolaveur Corporation*, discussed Mr. Fraser's paper as follows:

"I notice the formula showing the washing ratio. I just want to say that in the wet washing process it is usual to consider that this washing ratio is considerably more than is shown by the formula using free settling in water. In other words, we figure that the medium is built up considerably by the fines, and to illustrate my point I am going to substitute in that formula and instead of water we will assume that medium is built up to a point of 1.2; 2.5 minus 1.2 equals 1.3, and 1.3 minus 1.2 leaves .1, giving a washing range of 13 to 1 instead of the theoretical of 5 to 1 with water. I think that works out very generally in practice—that you actually wash in a larger range of sizes than indicated by the formula.

"In some of the outstanding wet systems of the country 15 or 16 to 1 is generally considered as the washing ratio in practice. I know of one going job that is washing at a much wider range than that. It is washing a 5/16-in. material down to 48 mesh, which figures out about a ratio of 20 to 1. I think that is a point to be clarified in speaking of all wet washing jobs.

"I was glad to hear Mr. Fraser speak of the washability or the characteristics of the coal in connection with washing. I think that point can not be stressed too much. I have often spoken and written of the economic point of washing coal, as that is where the "breaks" occur in the curves. In other words, let the break establish a washing point rather than setting up an ash or recovery proposition. This is caused by the character of coal, as Mr. Fraser points out."

***RAY ARMS**, Chicago, Ill.*, said: "Mr. Campbell has risen in defense of an extended sizing ratio for water, in which I bear with him, but I feel called upon to extend the ratio for air to some extent.

"Mr. Fraser has dealt strictly, in his formula, with the theoretical limits, both of free settling ratios and has made certain statements at the top of the second page concerning hindered settling ratios. The influence on settling ratio due to hindered settling is of variable increase, due to the fact that you have hindered settling to a greater or less degree. In certain kinds of wet washing equipment you have a very thick bed and the utmost in hindered settling. That is the kind of a washer I think Mr. Campbell referred to.

"Similarly in a dry table you have the utmost in hindered settling in air, for the simple reason that you have nothing to expand that bed but a thin moving current of air, a velocity so small that it will not sustain even the smallest particle without the assistance of the remainder of the bed. This fact is leading to a development in air cleaning along the lines of simultaneous classification and concentration. Mr. Fraser refers, in his paper, only to concentration. If, however, you combine in a single machine simultaneous classification and concentration, you increase the effect to a new settling ratio which is hard to define or to limit by mathematics—the actual results must be obtained by tests.

"It is a fact, however, that tests made recently on equipment with which I am most familiar, as well as other contemporary equipment, shows results in cleaning when compared to the sink and float washability curve far beyond the settling ratios as defined in this paper. We must look, therefore, for the reason for that increase in cleaning effectiveness, either in an increase of settling ratio, due to (*Continued on page* 544)

A dry cleaning plant of the Berwind-White Coal Mining Co.

DRY CLEANING *at the* BERWIND-WHITE COAL MINING COMPANY*

Plant Originally Designed For Hand-Loaded Coal, With Secondary Purpose Of Experimenting With Mechanical Loading — Approximately Twenty-five Percent Output Sent To Plant Now Is Mechanically Loaded Coal—Average Ash Reduction 20 Percent With Sulphur From 25 To 40 Percent—Rejection Averages 5 Percent — Plant Largest Coordinated Tipple And Cleaning Unit Built At One Time

By E. J. NEWBAKER †

AFTER listening to the experts, I suppose practical men at least will be ready to hear something about results. Although technical discussions are highly interesting and partly comprehensible to myself, I believe a great many other operating men here would be more interested in the actual results obtained from a cleaning plant. I will, therefore, state at once the results that we have obtained at a plant at one of our mines in Windber, and, if there are any questions afterwards that you would like to ask, I will try to answer them.

The plant in question was built and put into operation about a year and six months ago. After some eight or nine months of experimenting, carried on by the contracting engineers and ourselves, the plant was accepted. The delay in acceptance was caused by the fact that we were trying to make a perfect refuse rather than a clean marketable product. And our operating men in charge of the plant were so meticulous as to the appearance of the refuse that they finally got the rejects down to 2.5 percent while the plant had been built upon a 4 percent basis of rejects. Naturally, the resulting product was unsatisfactory. When the limit of rejections was raised to that described in the specifications, we immediately had satisfactory results and the plant was accepted.

The ash reduction varies from 15 to 55 or 60 percent, depending upon the character of the input. I suppose you wonder how we get such a tremendous variation in the ash reduction from the run-of-mine. The plant was designed originally for hand-loaded coal, with a secondary purpose of experimenting with mechanical loading. Those experiments have been carried on so that at the present time we are sending to the plant about 25 percent of the output in mechanical loaded coal. As you all know, machine-loaded coal contains a high and varying amount of refuse. Hence the variation in reduction of ash.

The average ash reduction at the present time is about 20 percent. The sulphur reduction varies from 25 to 40 percent, depending upon the character of the input. The average is about 35 percent.

The rejection or weight loss varies from 4 to 6 percent, averaging about 5 percent. However, if the plant were operating on hand-loaded coal only, it would meet our specification of a 4 percent reject.

The ash content of rejects varies, but will average about 35 percent. The sulphur content varies, but will average about 13 percent.

In connection with the variation and average percentage of ash and sulphur in the rejects, I wish to state that there is a great variation in the character of the material to be removed. It consists of iron pyrites, shale, fire-clay, and bone, with specific gravities varying from 1.45 with about 14 percent ash to 1.90 with 74 percent ash, and sulphur content of refuse varying from 2.5 to 35 percent.

Those are the figures of the plant performance. I believe it is the largest coordinated tipple and cleaning unit to be built at one time. We are following it with a second plant of similar capacity, but we have departed slightly from the dry principle. Possibly this is in accord with the new development of utilizing either wet or dry preparation or both as conditions may dictate. At any rate, we have departed from the dry system in our new plant to the extent of installing one wet unit which will handle coal from 4 to 1½ in.

I might say at this point that our percentage of large sizes is small. The coal is very friable and in machine-loaded coal as much as 70 percent will pass through a ⅜-in. square mesh. It is on account of this condition that we limit ourselves largely to dry preparation.

The deleterious effect of moisture, either free or inherent, has been clearly proved by experimental work carried on by the Bureau of Mines, and, as our Windber coal is a steam coal and the loss of heating effect of each 1 percent of moisture is equivalent to the same percent of ash, there is every reason for not taking out some ash and then putting back the same or a greater amount of moisture. However, the presence of moisture may not be harmful in coals used for other purposes, but that is a question which I will not attempt to discuss at the present moment.

If there are any questions that anyone wishes to ask in the operating direction, I will try to answer them.

***RAY W. ARMS**, Roberts and Schaefer Co.*, in discussing this paper, said: "The attitude taken by the Berwind-White Coal Mining Company in general, and Mr. E. J. Newbaker in particular, is probably a good bit in advance of the general trend of thought in connection with steam coal. Those of us who are in the business of selling coal cleaning equipment find that the chief objection to moisture originated with the metallurgical fraternity, or those who (*Continued on page* 569)

* Presented to the Fifth Annual Convention, Practical Coal Operating Men, Cincinnati, Ohio, May 8, 1928.

† General manager, Berwind-White Coal Mining Co., Windber, Pa.

E. J. Newbaker

General view of tipple

CLEANING COAL *at the* NEW RIVER & POCAHONTAS CONSOLIDATED COAL COMPANY*

By R. G. PERRY †

Plant Produces Six Sizes With Capacity To Produce Eight—Pneumatic Cleaning System Used — Complete Description Of Methods Employed And Results Obtained

THE following article is not intended as a discussion of the relative merits of various types of machinery, and for that reason an attempt has been made to limit it to a description of the plant in question.

We recently put in operation at one of our Berwind (W. Va.) operations a 5,000-ton capacity, six-track tipple, producing six sizes of cleaned coal under ordinary conditions, but capable of producing eight sizes if desired. The structure is a redesigned steel tipple, with the main part of the plant confined to the limits of the old structure so that it was somewhat of a problem to obtain the desired results. The plant was designed and erected by The Fairmont Mining Machinery Co., of Fairmont, W. Va., and the cleaning and dust-collecting plants were furnished by the American Coal Cleaning Corporation, of Welch, W. Va.

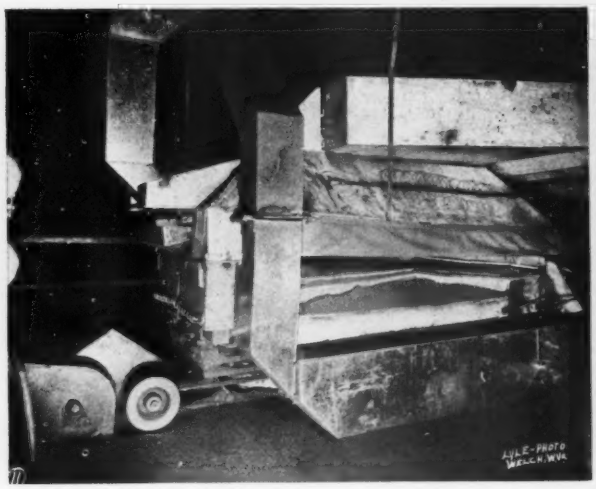
As nearly every operator has experienced, there are drawbacks to the marketing of wet washed coal, particularly the finer sizes, such as freezing of the coal in the car in cold weather, high

* Presented to Fifth Annual Convention, Practical Operating Men, Cincinnati, Ohio, May 8, 1928.

† Superintendent, Pocahontas Division, New River & Pocahontas Consolidated Coal Co., Berwind, W. Va.

View looking up shaker screens

Nut and pea coal air tables beneath shaker screens



Slack tables beneath old wet washer bins

Vibrating screens making separation of ½" x ⅛" and ⅛" x 0"

freight charges due to the added weight of water, loss of fuel value due to the moisture content with resultant limitation of market, and the appearance of the coal. It is surprising how much coal is purchased on its appearance rather than analysis. These objections may be met, except as regards appearance, by some form of dryer, but it requires additional outlay of capital for the plant and more handling of the product with resultant degradation. For these reasons it was decided to use dry cleaners on all sizes that we found uneconomical to hand pick.

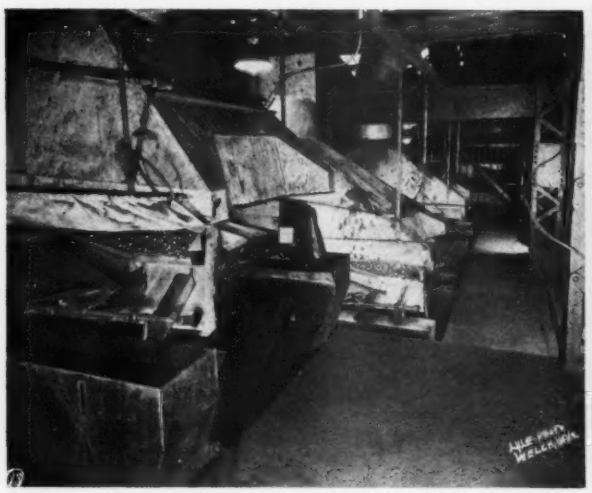
The six sizes of coal ordinarily made are: Lump over 4½ in.; egg under 4½ in., over 2¾ in.; stove under 2¾ in., over 2 in.; nut under 2 in., over 1 in.; pea under 1 in., over ½ in.; and slack under ½ in. The two additional sizes which it is optional to ship are diversions of the slack, giving up three sizes under ½ in., namely, ½ x ⅛ in., ⅛ in. x 0 as screened, and the dust collected.

The percentages of sizes handled are approximately:

	Percent
Lump	14
Egg	20½
Stove	4½
Nut	11
Pea	12
Slack	38

At this plant we are handling coal from both sides of a ravine, the dip of the coal being such that the drift openings on one side, called No. 1 Mine, are well up on the side of the hill, while on the other side where we have only one opening the mine, called No. 2, is very little above water level. This made it necessary to have two dumping points, as the obstacles to bridging the ravine with a tramroad were so great as to make it uneconomical. The coal from No. 2 Mine is dumped into a small receiving hopper, which feeds an inclined pan conveyor. This pan conveyor discharges into a 22-ton hopper into which the coal from the No. 1 or upper openings is dumped direct from the mine cars.

Now to follow the coal through the plant. A reciprocating feeder feeds it onto a 10-foot shaker, where a screen plate with 2½-in. round holes relieves the load, the undersize passing over a 1-in. round-hole screen and the oversize passing over the lower end only of this 1-in. screen. This arrangement is made possible by having a double-deck screen at this point, with the lower deck extending beyond the upper. The oversize from the 1-in. screen passes over a 2-in. round-hole screen, where the undersize or nut is removed to a receiving hopper directly underneath, and the oversize traveling down the shaker passes onto a 6-ft. shaker in line with the upper 10-ft. section, on over a 2¾-in. round-hole screen, where the stove size is removed to a receiving hopper directly beneath, and the oversize travels on over a 4½-in. lip or step screen. The undersize or egg at this point feeds directly onto the egg picking table, and the oversize feeds off the end of the shaker to the lump picking table. The cleaned product from the lump and egg picking tables is lowered to the railroad cars by steel pan loading booms, the pans or



Stove, nut and pea tables beneath shaker screens

In the bag house, where coal dust is removed from the air

flights of which are continuous with those of the picking tables.

To return to the undersize from the 1-in. screen, this product feeds by gravity to a pair of high-speed shakers, which have ½-in. square holes. The oversize or pea coal feeds by gravity to a receiving hopper directly over its cleaning table, while the undersize or slack is delivered to a short belt conveyor which discharges into the boot of a bucket elevator. This elevator delivers its load onto a scraper conveyor running over the top of some old bins, originally used as part of an old wet washer, and which are now used as storage for the uncleaned slack, insuring flexibility of this part of the plant. By means of gates in the bottom of the scraper conveyor the coal is fed to a battery of four "Hummer" vibrating screens, where a separation is made into two sizes, ½ x ⅛ and ⅛ x 0, the ½ x ⅛ dropping into sections of the bin directly under the screens and the ⅛ x 0 feeding to a scraper conveyor, which delivers it to the proper sections of the bins.

We now have the coal sized and ready for cleaning.

The size of the storage bins for the two sizes of slack permits us, if desired, to clean and load these two sizes separately, but I'll describe it as one operation, as under ordinary conditions the treated products are handled by the same conveyors and remixed to ½ x 0 products. The two sizes are fed by gravity to their respective air cleaning tables, adjustable Y-tables being used here. Three products are made, as with all the other tables, clean coal delivering to a scraper conveyor which in turn delivers to another short scraper conveyor and which delivers to the railroad cars by a telescopic chute, or by means of a short chute delivers to a belt conveyor discharging to a main remixing conveyor. The second or middling product, if one wishes to call this a product of the separation, delivers by means of a scraper conveyor to the same bucket elevator as handles the uncleaned slack, and is returned to the bins for retreatment, and the third product or refuse is delivered by its conveyor to the main refuse conveyor which runs the full length of the main tipple structure, parallel to the shaker screens, and delivers to a refuse bin alongside of the railroad tracks. As in all cleaning operations where the specific gravities of the materials handled differs but little, it is practically impossible to establish a clean-cut line between the refuse and the clean product. For this reason we take this middling cut, which carries too much refuse to be allowed to go into the clean product and too much clean coal to be thrown away.

The other sizes are kept in the main tipple structure, their cleaning tables being located directly below their respective sections of the shaker screens and over the loading booms. Except for the type and size of table used, the treatment is the same for these sizes. The pea and nut coal are handled on adjustable Y tables and the stove on a half-Y table. As mentioned before, the uncleaned coal is fed from the shaker screens to a hopper directly beneath. This hopper also serves the purpose of taking care of surges in the process; for instance, we may have a mine car dumped which carries principally lump, or it may carry a large percentage of the smaller sizes. A reciprocating feeder delivers the coal from these surge hoppers to the cleaning tables, the clean product going directly to a belt loading boom in each case and thence to the railroad cars. The middling product is delivered by the main middlings and rescreen conveyor to a bucket elevator, which returns it to the upper section of the shaker screens to repeat the process, and the refuse passes directly onto the main refuse conveyor to be delivered to the refuse bin. Mention should also be made here that there are rescreen plates in the reciprocating feeders to the cleaning tables and in the short chutes which deliver the cleaned coal to the loading booms. This is to take care of degradation in the process which we found necessary because of the extreme softness of the coal.

Looking down the track. Dust collection chamber on the right

Provision has also been made in the plant for the handling of a middlings product from the egg and lump picking tables. In passing, I'll merely mention that the refuse from these picking tables is thrown direct onto the main refuse conveyor. The middlings, which may carry alternate streaks of coal and refuse, is thrown onto a short conveyor delivering to a roll crusher, the crushed product going to a short bucket elevator which discharges onto the inclined pan conveyor from the No. 2 dump hopper to the main dump hopper and thence to the shaker screens again and over the air cleaning tables to be separated.

Stove air table with side curtain raised to show discharge of refuse, middlings and clean coal as well as raw coal by-pass

Under ordinary conditions a plant such as the one described would fill the air with dust. To take care of this a dust-collecting system has been installed which effectively handles all the dust made by the pneumatic tables. This system consists of a hood over each cleaning table, with a large-diameter suction pipe; all of these discharge to one main suction pipe operated by a multivane fan. This fan delivers by a single pipe to the bag house, where the dust is deposited and the air escapes through the bags to the outside. A brief description of this bag house might be of interest here. The dust-laden air from the fan is discharged into large chambers in the top of the bag-house structure, where the velocity is lowered, permitting the heavier particles to settle by gravity, although this has no direct bearing on the result other than the lowering of the velocity, as the only outlet from these expansion chambers is through openings in the bottom. There are 990 of these openings, 7 in. in diameter, to each of which is fastened one end of a bag, the other end of each bag being fastened to a similar opening in the floor of the bag house and directly under the opening in the expansion chamber, so that the bags might be more properly called tubes. These bags or tubes are made of a good quality of broadcloth, with the sheen of the cloth on the inside of the bag. The air under a water gauge of about 1 in. filters through the sides of the bags, and the dust which settles out here, and because of the slick surface of the cloth on the inside of the bag, settles to the bottom and through the openings in the floor to the dust-receiving hoppers directly beneath the floor. From here it can be delivered by screw conveyors to the power-house conveyor and thence to the power house for use in pulverized fuel boilers, or it can be delivered to railroad cars and shipped as a separate product or as part of the slack. This dust carries an ash content slightly below that of the clean slack so it has no detrimental effect when mixed.

Another interesting feature of the plant is the remixing conveyor, which can be used or not, as market conditions warrant. This remixing conveyor is in that part of the structure which carries the movable end of the loading booms, and is so located that any or all the booms, including the slack belt conveyor, can be raised from their car-loading positions so as to discharge onto it. By means of this we are able to mix any combination of the cleaned sizes desired and ship them as such. This conveyor is also used to deliver coal to the house coal bin for local use.

Sink and float tests have been made on uncleaned coal, and the results obtained

by these tests on coal screened to ½ x ¼ in. are tabulated below as typical:

		Weight Percent	Ash Percent
	Float @ 1.25	0.0	
Sink @ 1.25	Float @ 1.30	40.7	2.49
Sink @ 1.30	Float @ 1.35	27.6	4.62
Sink @ 1.35	Float @ 1.40	12.3	8.77
Sink @ 1.40	Float @ 1.50	9.8	15.16
1.50 @ 1.50	Float @ 1.60	1.6	26.44
1.50 @ 1.60	Float @ 1.70	1.8	34.07
1.50 @ 1.70	Float @ 1.85	0.9	43.48
1.50 @ 1.85		5.3	75.50

From this we obtain the cumulative results:

	Float		Sink	
Sp. Gr.	Weight Percent	Ash Percent	Weight Percent	Ash Percent
1.25	....	....	100.0	10.28
1.30	40.7	2.49	59.3	17.3
1.35	68.3	3.35	31.7	25.3
1.40	80.6	4.18	19.4	35.6
1.50	90.4	5.27	9.6	56.6
1.60	92.0	5.74	6.2	70.9
1.70	93.8	6.28	6.2	70.9
1.85	94.7	6.85	5.3	75.5
1.85	100.0	10.28		

These tables are given to show the type of coal handled, and even these figures fluctuate widely. It is possible to go into a lengthy discussion here of the washability of this coal, but this would be of interest to the technical men only, so I'll limit myself to the fact that we are getting a slack with an ash content of 6.5 to 6.75 percent.

The plant described has given satisfactory results, and the main difficulties encountered were caused by our inability to make adequate screen tests over a protracted period of time previous to designing the plant, with the result that some parts were overloaded and others were correspondingly underloaded. Provisions have been made to take care of this, and the results are such that we are remodeling another of our tipples, in this case a wooden one, to clean coal in a similar manner.

COL. W. J. O'TOOLE, *American Coal Cleaning Corporation,* discussed this paper, saying as follows:

"Mr. Perry has just given you a description of the tipple and cleaning plant at the Berwind Operations of the New River and Pocahontas Consolidated Coal Company. In stating the results obtained in this plant he has given average results rather than the results which have been obtained during the past couple of months. As is natural in any cleaning plant of this character the results should get better gradually until the operators become familiar with the mechanism.

"The plant during the past two months has been producing 6.3 percent ash in the cleaned coal.

"The difficulties in making adequate screen tests before this plant was put in operation were due to the fact that only R. O. M. coal had been shipped previously from it and the area from which half the tonnage is now coming was entirely closed down. Screening tests were made on the coal from another mine of this company which produced prepared sizes. The difficulties encountered, however, were of small consequence because a plant of this kind must necessarily be able to take a wide variation in sizes.

"Although it was Mr. Perry's intention to limit his remarks to a description of the plant and not the relative merits of the various types of mechanical cleaning machinery, this company has had considerable experience along this line. Before going into the matter of dry cleaning on a large scale a small plant, first consisting of one separator on the 1¼ x ½ in. size was installed at their Newhall operation. This was later extended to include a separator on the 2½ to 1¼ in size. The experience gained in the operation of these units was the basis on which the larger installation was made. The larger installation replaces a wet washing plant which had formerly been operated by the company.

"The term "Middlings" used by Mr. Perry may be confusing to persons not entirely familiar with the pneumatic method. In ordinary operation the separators discharge two final products, clean coal and refuse. They are capable of delivering a middle product, boiler coal or low grade fuel.

"In the operation of the separators there is discharged from them a portion of the product in a special channel which is returned to the crude feed and which is commonly and incorrectly termed 'Middlings.' This is not a true middle product and is recirculated only as a part of the process of separation. It does not accumulate in the system nor does it build up. The quantity in circulation is constant. The operator is able to determine usually by visual inspection the point on the separator beyond which pure refuse is being discharged, and another point beyond which clean coal is discharged. Between these two points there is a section from which not over 15 per cent and usually not over ten per cent of the product is discharged, which is a mixture of coal and refuse. This is returned to the crude feed for the reason that as a whole it belongs in neither product but the individual particles forming it upon their return find their proper place either with the clean coal or the refuse. When a true middle product is taken off it is still necessary to recirculate this so-called 'Middlings.'

"As Mr. Perry has said, six sizes are usually shipped from this plant, but it is possible to ship eight. At the time the plant was designed it was considered desirable to make this provision, due to the tendency to a larger number of sizes at bituminous mines. The additional sizes possible under this arrangement are ½ x ⅛ in. buckwheat, ⅛ in. to 0 slack and dust. It is considered that there is a potential market for the dust in the increasing number of powdered fuel plants now going in.

"Mr. Perry has described the dust collecting system in this plant. This system, it may be said, is accomplishing everything that was expected of it. It will be remembered that a discussion of dust collection was held on this floor last year and at that time I stated there was a plant of this type handling 75,000 cu. ft. of air per minute and had been in operation during a period of eight months. This plant now has been in constant operation for a period of almost two years. The plant under discussion has now been in operation since November, handling a considerably larger quantity of air, it being the first plant of this type in connection with dry cleaning plants installed in this country. 990 7-in. diameter bags may seem to be a considerable installation. These bags, however, are placed very close together and require only a floor space of 17 ft. by 41 ft. It should be remarked here that no method is provided, neither is any necessary, for the cleaning of the bags.

"It will be noted that sizes above one-half inch are made to meet the domestic market demand and that sizes under a half inch are divided into ½ x ⅛ and ⅛ to 0. Before the advent of the Y table it was necesary to make the following sizes: ½ x ¼, ¼ x ⅛, ⅛ x 1/16 and 1/16 to 0. The reduction in the number of sizes facilitates the operation of a plant.

"It will be noted as a feature of this plant that the separators treating the domestic sizes are placed directly under the shaker screen and discharge directly to the loading booms. This reduces to a minimum the degradation on these sizes, an important factor, on account of the premium over slack prices which such sizes bring."

PRINCIPLES OF DRY CLEANING OF COAL

(*Continued from page* 539)

hindered settling or some other added feature that is incorporated in these machines. Those added features may be defined as simultaneous classification and concentration, or they may be accounted for by the effect of the deck surface itself on the material which is nearest adjacent to it, namely, the slate, as differentiated from the material farthest away from it, namely, the coal.

"Therefore we can expect as air cleaning develops further the same effect as though the actual settling ratios were being increased. Up to date we will have to admit that we can't claim 16 to 1. We have produced a practically perfect cleaning on a 4 to 1 ratio and, to a certain extent, on a 6 to 1. That for the purposes intended is sufficient in ordinary coal cleaning plants. I doubt if ever the settling ratio in air will exceed 8 to 1."

(In replying to questions, MR. FRASER stated:)

"It has been generally observed, in the operation of gravity separators of various types, that the actual separation size ratio greatly exceeds the free settling ratio. The condition existing in operating commercial machines is usually described as a 'hindered settling condition.' Extensive investigations have shown that a great many complex factors contribute to the increase in separation ratio under such conditions. It is suggested that those interested in going into this subject fully should consult the publications referred to in the brief bibliography herewith. In jigging the principal factor is probably the rapid initial acceleration of small heavy particles. In trough washers small particles on the bottom are subjected to lower velocity currents than larger particles that extend farther up into the stream. While this is advantageous in removal of fine refuse, it tends to throw fine coal into the refuse discharge and calls for rising current classifiers in circuit with the trough washer.

"Many commercial machines are really made up of two or more elementary separators combined in one unit, and are thereby able to handle a wider range of sizes than any one of the component elements would. This tends to obscure the principle of operation, but these principles have to be taken into consideration, as it is possible to combine operations in such a manner that one will reverse the effect of the other."

GENERAL TIPPLE PRACTICE*

By C. P. ANDERSON†

Design Of Tipple Should Be Determined By Characteristics Of Coal Seam —Motors For Conveyors, Screens And Loading Booms Should Have Starting Control At One Central Point, But Stop Controls At Several Points— Screen Capacity Should Be Fifty Percent Oversize to Take Care Peak Loads

TIPPLE and tipple practices cover a wide scope of territory, ranging in construction all the way from just a cheap wood chute, loading coal direct into the railroad cars up to tipples with every size of screens, making coal in all grades from lump to dust.

In the laying out of the tipple, the first thing necessary is to consider the seam of coal, whether, with proper care inside the mine, the coal will be clean enough to remove the impurities by hand, or whether it will be necessary to build mechanical cleaning plants to clean the coal either by wet or dry process.

In this paper we shall treat mechanical cleaning as a separate subject and not built into the tipple proper. We will also assume that the coal with the proper preparation on the inside can be cleaned by the use of picking tables and loading booms.

In the building of a tipple, I believe that it should be so constructed as to take care of 50 percent over-production; that is, 50 percent more production than is expected.

The machinery should be constructed with this end in view, including all the electric motors and other mechanical equipment as well. The tipple should be at least 16-ft. centers between tracks, which gives plenty of room for trimming platforms, and also plenty of room in the tipple so that the machinery is all readily accessible and not crowded up.

We will consider that in this tipple we are making five sizes of coal; that is, lump, egg, nut, pea and slack. When the coal is dumped from the mine car, it should either go directly into a feeder or into a weigh pan, and from the weigh pan into a feeder. I believe that the tipple should be equipped with a reciprocating feeder, as that permits the feeding of the coal into the screens without over-crowding. The type screen used, of course, will naturally depend upon the fracture of the coal, and in the New River District, I am very partial to the lip screen, which is self-cleaning. Owing to the fracture of the coal, this works very well for the larger sizes.

The main screens should be built in two sections. I might mention that at this time there is quite a difference of opinion as to the type screens, and possibly another screen all connected together would be as efficient.

The coal when coming off the feeder should be delivered onto the small size screen, and the nut, pea and slack should drop through these screens, and the lump and egg carried on to the next section, the lump passing over these screens and the egg dropping through.

The smaller sizes—that is, nut, pea and slack—should be carried on to a separate screen and separated. The lump, egg, nut and pea should be loaded into the railroad cars with loading booms. Where all of the coal is delivered onto the boom, there should be a re-screen and the degradation carried back into the slack car. Where the coal is not very dirty, standing boards may be attached to the loading booms, where the inspector, pickers and trimmers may remove the impurities before the coal goes into the railroad cars. However, if the coal is dirty, it will be necessary to have picking tables, of course, just before the coal is loaded onto the boom. These picking tables, of course, should be equipped with refuse conveyors, which will carry the refuse to the slate bin, where it can be disposed of with larry cars and carried to the slate disposal.

I believe each tipple should be equipped so as to mix any size coal that may be desired, and should be so equipped that mine-run can be handled through an emergency mine-run chute, or same could be delivered to the lump track and loaded over the lump loading boom.

Where the coal is very dirty, it is a good idea to separate the different sizes for cleaning purposes, and then throw them back together to make mine-run.

The tracks at all tipples should be on a 2 percent grade so that cars will run freely and each track should be equipped with a car retarder. This allows the dropping of the cars a short distance at a time, so that they can be trimmed, and at the same time saves breakage.

For all tipple machinery, extra parts should be carried on hand, so that in case of a break-down repairs can be made with a minimum of delay.

All tipple machinery should be thoroughly inspected, either at the end of the day or in the morning before the tipple is started, preferably, after the day's work is finished, so that the necessary repairs can be made while the tipple is idle.

Some one man should be held responsible for the tipple and should also see to it that everything is thoroughly greased and oiled. In the operation of tipples, plenty of labor should be used at all times so that the tipple can be operated with a minimum of delay. The wiring of the tipple should be push-button type, so that the tipple can be stopped from any point. However, from a safety standpoint, it should only be started from one point.

Signal bells should be installed so that any message desired to be conveyed can be done without beating on steel rails or other crude methods of signalling. The tipple should also be thoroughly lighted by sky lights as well as artificial lighting.

All tipple machinery should be guarded so as to prevent accidents. Tipples should be constructed with clearance sufficient not only to take care of present day railroad equipment, but with an eye to the future.

My reason for 50 percent over-production when constructing a tipple, I shall endeavor to explain to you. You are all mining men and you know how necessary it is at times to speed up a tipple, in order to make up lost time on account of accidents on the tipple or at other points. When the capacity of a tipple is taken into consideration, as a rule, we figure the mine's production and the percentage of the different sizes, we intend making. We may arrive at a capacity of 1,500 tons per day, but there are times when the peak load will be at the rate of 2,000 tons or better, and it is a very difficult thing to figure just the percentage of the different sizes we are going to get. There are times when some mine cars will be practically all lump, others when the sizes will be nut and pea. These conditions are such that they just can not be regulated and the only remedy I can think of is to build the tipple so as to take care of this irregular over-production.

Naturally, all loading booms should be equipped with electric motors.

It is not always possible to have the necessary room to build the tipple just as I have outlined here, and to cover that situation, I will describe a tipple where they did not have the space, therefore had to use bins for the smaller sizes.

The tipple in question was built to serve a shaft mine. The coal is reasonably clean, and is watched very closely to see that the miners clean their coal before it is sent outside. The coal is hoisted in mine cars and dumped into a weigh basket. From the weigh basket, it goes into a reciprocating feeder, which feeds it onto 2-in. lip screens.

The stove, pea and slack, of course, go through this 2-in. screen, while the lump and egg pass over to another section of screen. The lump passes over this section, and the egg drops through. The lump is delivered onto a loading boom. The egg coal is also delivered onto a loading boom. The smaller sizes, slack, stove and pea, are carried by elevator buckets up into a bin. Here it is dumped onto Parrish type screens, where it is separated, making stove, pea and slack.

The bin is a three-compartment bin, one for stove coal, one for pea, and one for slack. The stove coal is delivered onto a picking table and from the picking table into spiral chutes, which deliver the coal into the bin with a minimum of breakage. The pea coal is also delivered onto spiral chutes and delivered into a bin with a minimum amount

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† Chief Coal Inspector, New River Co.

of breakage. The slack, of course, drops directly into the slack compartment.

These screens are arranged to make pea and slack, or pea and stove. At the bottom of this bin, for loading purposes, this stove coal passes over a lip rescreen, and the degradation is carried back to the slack compartment.

Telescoping chutes are used; a heavy round pipe, cut up into sections, which are all connected up with chains and wire rope, hooked up to a windlass. These telescoping chutes go to the bottom of the railroad car, and in loading the chutes are left full of coal all the time and therefore have a minimum of breakage.

The pea coal passes over a double-deck vibrating screen. The degradation is carried back into the slack compartment. This coal is also loaded with telescoping chutes, the same as the stove coal. The same applies to slack coal.

In the handling of mine-run, the screens can be veiled and carry the mine run on the lump boom, or by-pass it through the regular mine run chute and load it on the slack track.

The loading booms are equipped with boards on the side for pickers and inspectors to stand upon, therefore getting a chance at the slate, which might be in the coal, before it goes into the railroad cars.

The tracks all have a good grade and are equipped with car retarders.

You, no doubt, will think this is a very simple tipple in a way. It is, of course, but the seam of coal is practically free from impurities and an elaborate layout is not required.

CARL HAYDEN, of the *O'Gara Coal Company*, discussed Mr. Anderson's paper, as follows:

"I think Mr. Anderson has covered this subject very completely. There are, however, a few minor details that I have in mind in connection with the design of the tipple. First is the consideration of the various types of drive and main screens themselves, there being a number of different types of drives designed by different individuals, each of which has certain advantages.

"In the mixing of various sizes it is very essential that these changes be made with the minimum loss of time. The tipple should be designed to incorporate the particular type of hoisting cage, skip and so forth, and at the present time, in view of the introduction of mechanical loading, it is very necessary to allow additional picking and cleaning facilities to take care of the increased amount of impurities. The tipple that was designed a few years ago for hand loading is now obsolete in mines loading mechanically. It should also provide ample conveying equipment to take care of this extra amount of refuse. In designing a tipple, it is well to keep in mind the possibility of reclaiming this refuse at certain times in the future when conditions may warrant.

"In the construction of the new tipple it is very desirable to employ either a firm of consulting engineers who make it their business to design tipples, or a contracting company who maintain their own engineering department, and in this way capitalize on the experience they may have had over the entire country. It is also very desirable to secure, in addition to the outside engineering service, the assistance and advice of the local employes who probably know more than anyone else about the local or particular characteristics of the coal itself.

"I might discuss briefly a tipple which has been recently completed in southern Illinois at one of our mines in Harrisburg, which has incorporated, I think, most of the suggestions and recommendations that Mr. Anderson has made. This particular tipple is controlled entirely by one man from a central point. He starts and stops all the machinery from the screens to the picking tables, the loading booms, raises and lowers the loading booms, handles the car retarders, and in a way manages the entire tipple.

"This particular tipple has been designed with approximately twice the picking surface on the picking tables as would ordinarily have been put in for a hand-loading mine, although to date no mechanical loading is being done. The tipple has also been laid out so that the refuse, which is now either thrown away or burned in the boiler room, can be put through a breaker or other type of equipment that might salvage this refuse.

"This tipple has been designed with a mixing conveyor which will mix practically any and all sizes after having been separated and picked separately. By the use of this mixing conveyor and various valves and butterflies in the screens themselves, it is possible to make 25 or 26 individual sizes. The tipple itself ordinarily makes five standard sizes and has a rescreener to make the number 2, 3, 4 and 5.

"The coal can be separated into various sizes, picked separately, mixed back together into mine run. This tipple is wired entirely in conduit, and skylights are provided over the picking tables. A concrete casing around the head frame portion of the tipple itself provides not only rigidity for the entire structure but also encases the steel members and has a tendency to prevent the decay or rot of the particular members around the shaft itself."

UNDERGROUND TRANSPORTATION AT EBENSBERG

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required work easily. Equipment is made interchangeable as near as possible. The movement of all transportation units is controlled by one man. Coal is moved in large units without unnecessary stoppage. The coordination of these factors has resulted in a transportation system which works smoothly and effectively. The correct solution of the transportation problem is largely responsible for the satisfactory production of a large tonnage from a low seam at Colver.

(In answering various inquiries, MR. FLEMING further stated:)

"We have a central method of controlling our haulage equipment. There is a man stationed immediately outside the tunnel portal. This man is in telephone communication with all sidetracks and with all important junction points. It is his duty to keep in touch with every locomotive crew and to know how many cars, both loaded and empties, they are handling, where they are at, and if there are delays, and it is his duty to take means to overcome that delay. So that with this close supervision of the transportation units we attribute a good deal of the success of the system to that.

"The weight of rails on the main dip heading on the loaded side is 70 lbs.; on the empty side 45 lbs. On some of the main section entries which do not have heavy grades we use 45. Wherever there is an excessive grade we try to use 70-lb. rails because we find it is better that way.

"In order to expedite the movement of our coal up this main dip heading, which you will note from the number of times I mentioned it is an important one, because over half the tonnage is moved up over that grade, we use a 15-ton locomotive as a pusher on the operating of that grade. It assists both the 22½-ton locomotives up the grade and one 15-ton locomotive which is operating for 2,000 feet down the grade. We find it is better to do this; that we can haul 60 cars in a trip in that way and get along with it very nicely.

"I might say in regard to power distribution at our own particular mine, that that is taken care of pretty well by the central control of the trips; that is, it keeps them from synchronizing from different sections of the mine to keep the starts separated. Thus it distributes the demand for large amounts of power at one time.

"As I mentioned, we also have a substation about half-way down the trip section, which maintains the power up to a fairly good standard of 250 volts. The sub-stations for different sections of the mine are interlocked in such a manner that when one is pulling a little stronger than the other, it can draw power from one which is not pulling strong at that time."

SUPPLYING POWER THROUGH AUTOMATIC SUBSTATIONS

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readily than our railway and power customers, for which we are very grateful to the mining customers.

"On the maximum demand systems there are both simple and complex maximum demand controls. The one mentioned by Mr. LaViers is a d. c. over-load relay. You can also secure an integrating system, which will measure the integrated demand and a relay which will anticipate the reaching of your limit and cut off extra feeders or surplus power so as to limit the peak. This may save you quite a bit in the power bill.

"In connection with the pumping system, I would like to suggest the graphic ammeter as a very useful instrument in telling the story of the pump operations. It will show you that the pumps are trying to start and are not getting on the line by the current fluctuation, and also calibration of the ammeter in terms of pump load will show you something about gallons per minute and the number of pumps running."

The American Engineering Standards Committee has approved as tetative American standard the code for "Ladders and Stairs for Mines," developed by the Standardization Division of the American Mining Congress and submitted by them as sponsors. The date of approval was May 26, 1928, and the Engineering Standards Committee designating number is M 12-1928. It is procurable from the A. E. S. C. or the American Mining Congress.

FUNDAMENTALS *of* COAL CLEANING*

By J. B. MORROW †

Definition Of What Is Meant By "Clean Coal" — Analogy Between Mechanical Coal Preparation And Ore Concentration—Principal Factors In Determining Design And Selection Of Coal Cleaning Plant Are, The Physical Characteristics Of The Coal Seam, Use Of Prepared Product, And The Climatic Conditions

DURING the last few years the technical press has carried quite a number of articles on coal cleaning and the advertising pages have been well sprinkled with the claims of manufacturers for their respective processes. We read that this machine or this process will do more efficient and cheaper work than any other method, so it has become rather difficult for the operator to decide as to what type of apparatus is best suited to his needs. It might not be amiss, at this time, to ask just what is meant by "Cleaning Coal."

There are no definite standards in the bituminous industry as to what constitutes clean coal, but the conditions vary considerably depending on location and market and the use of the prepared product. Some recently published results, from a western operation, show that a 1 x 3-in. nut, after cleaning, contained 10 percent of impurities at a higher specific gravity than 1.60 and a 3 x 6-in. egg contained 7 percent of the same class of impurity. For the particular market conditions under which this coal is produced and in competition with the other coals in that district, this was considered to be a clean coal and was readily saleable as such and it is rather doubtful as to whether a much cleaner product would have commanded any premium in this particular market. As a comparison with this, we might quote some other figures showing 3 percent of impurities heavier than 1.60 specific gravity, on an eastern bituminous coal, at a size of 1 x 2½-in. or 2 percent impurities of the same nature in a 2½ x 4-in. coal and both these coals were considered to be unusually clean products on the competitive market.

The anthracite operators, on the other hand, have adopted certain definite standards for their product and if the coal, as shipped, contains any more impurities than the allowable percentage as noted below the cars are dumped and recirculated through the breaker.

ALLOWABLE IMPURITIES IN ANTHRACITE DISTRICT

Coal	Size	Allowable Impurities % slate	% bone
Egg	2½" x 3 7/16"	2.0	2.0
Stove	1 9/16" x 2½"	3.0	3.0
Chestnut	⅞" x 1 9/16"	5.0	5.0
Pea	½" x ⅞"	8.0	
Buck	5/16" x ½"	10.0	

Of course most of the companies in the anthracite district are producing a much cleaner coal than these figures would indicate and they are simply used to indicate the quality of coal that certain districts consider to be a marketable product.

The question of just what constitutes impurities that should be rejected is another very vague matter, as in some districts the question of what constitutes an impurity may depend more on the looks of the product than on the actual percent of ash. In general, it may be said that the sales department would object to the presence of any impurities that will sink in 1.60 specific gravity. Also, there may be sufficient banded impurities in a lump of coal to spoil the looks of the same even though the percent of ash of that particular lump will show it to be of an average quality with the rest of the shipped product.

A. B. Kelley, Chairman of the second session on coal cleaning

In general, metallurgical fuel is usually sold on an ash basis while the domestic product is more often governed by the matter of appearance. Even a cleaned domestic egg coal can contain 2 percent of impurity which is hardly evident on visual inspection and can only be determined by specific gravity tests. In other words, a 50-ton car of egg coal with 2 percent of impurity contains 1 ton of practically incombustible matter, but at the same time the coal is considered as a clean fuel.

Fundamentally the general principles of concentration of material are the same whether they be applied to ore or coal, dry or wet cleaning, flotation or magnetic separation, and in this connection a study of the ore concentrating methods now in use or discarded will very greatly assist in the economical and efficient solution of the coal cleaning problem.

It is a common idea that the metal practice is not analogous to coal on account of the difference in value of the products, but when it is considered that some of the large concentrators are operating on ore containing not over 2 percent copper, there is really not so much difference.

The fine grinding problem is not encountered in coal cleaning nor is the disposal of a large tonnage of tailings and the consequent high cost of tailings storage and water reclamation. The actual costs covering the total expense of operation of flotation units, tables and classifiers, thickeners and filters, in a large western concentrator amount to only 9.5 cents per ton of feed and this is certainly comparable with coal cleaning operations on similar units.

While, perhaps, it is treading on somewhat dangerous ground, I would like to venture the opinion that the metal mills are far ahead of us in the art of concentration and we have a great deal to learn from their practice, both as regards the efficiency of mill layouts and also from a standpoint of mechanical operation.

The greatest difference between ore concentration and coal concentration is in the size value of the concentrated products. In metal practice a pound of copper has the same potential value whether it be in a lump of native copper or in finely divided flotation concentrates but in coal there is a variation in value depending on the size of the product and not necessarily related to the actual heat value, so that in the proper design of a cleaning plant it is necessary to study the economic significance of the difference in value according to grade and size and it is rather unfortunate that the greatest cost in cleaning lies in the treatment of the finer sizes which, in general, have the least value. This is true in both dry and wet concentration. In ordinary commercial work it is often impossible to be able to justify the necessary expenditure so that the efficiency of the cleaning operation will be the same on the fines as on the coarser sizes.

In Taggert's "Handbook of Ore Dressing" he states that "Concentration is a manufacturing operation involving the production and sale of the finished product" and, speaking of the economic significance of difference in grades, he goes on to state that "There is both a technical and economic problem and the economic factor is the more important" and this is particularly applicable in the case of coal preparation. Quoting Taggert again, he states that "The mining regions are dotted with monumental failures, not the least of which are those where the technical problems of production have been solved but the profitable disposal of products yet awaits solution."

There are certain fundamentals in the operation of cleaning plants which are applicable to all processes. The major factors might be stated relatively to be:

Constant feed to the separating unit.

Continuous running during the operating shift.

Constant supply of separating medium—air or water.

Constant and uniform supply of power.

* Presented to 5th Annual Convention, Practical Operating men, Cincinnati, Ohio, May 9, 1928.

† Research Engineer, Pittsburgh Coal Co., Pittsburgh, Pa.

The violation of any one of these fundamental principles inevitably leads to a decrease in the possible efficiency of the method used and yet there are many instances where one or more of them are violated.

To show the effect of variable feed and uneven operation, the following are the ash results on the refuse from operating units while working under normal conditions and also sampled at the time the feed was just going on or off:

	Normal Operation	Irregular Operation
Percentage of ash.....	52.8	18.0

Some of the principal factors in connection with the selection and design of a cleaning plant might be stated to be as follows:

Characteristics of the coal.
Percent refuse in coal.
Quality and use of the final product.
Capacity of plant.
Climatic conditions.
Available mill site.

Characteristics of the Coal

Enough has been written on the characteristics of the coal in different parts of the country to show the absolute necessity of careful attention to this feature before proceeding to design the plant. The day of the ready-to-wear coal cleaning plant is fast disappearing and the most successful future plants are going to be those in which the utmost care is taken to carefully consider the particular characteristics of the coal to be treated as they may affect the cleaning problem.

By the characteristics of the coal we mean particularly their availability to separation, this being influenced by the percentage and specific gravity of the clean coal, the percentage and specific gravity of the middling or bone product and also the refuse. It is rather obvious that one type of plant will not give the same result when working with a product with 90 percent of clean coal at a 1.40 specific gravity and a high specific gravity and consequently high ash refuse, as it will on a coal with 70 percent of float at a 1.40 specific gravity and with a carbonaceous refuse with low specific gravity and consequently low ash. Some coals require crushing to free the impurities and others again are not helped appreciably by this treatment. As the percentage of fines, say, minus 5/16-in., in the feed gives the most trouble in separation in either wet or dry plants it is most certainly advisable not to do any finer crushing than that which is necessary in order to accomplish the desired results. Perhaps this is particularly true in the case of coal containing a large amount of flour sulphur which, on grinding, tends to go into the minus 48-mesh material and in that form it is very difficult to make a separation with any process excepting possibly oil flotation.

Percent of Refuse in Coal

The influence of the refuse loss varies in different localities. For instance, if only 3 or 4 percent of refuse is being wasted from the cleaning plant and this refuse contains one-third coal, it does not have the same effect on the cost as in the case of a plant with 15 percent refuse and again with one-third loss of coal. In the first case the actual coal loss is considerably less than the operating cost and in the second case the item of coal loss may possibly be greater than the operating cost and in that case it becomes the most important factor. In other words, in a coal with a low percentage of refuse in the feed the cost of operation is the more important, and in coal with a high percentage of refuse in the feed it will be cheaper in the end to have a higher first cost for investment and a higher operating cost in order to reduce the refuse loss.

In this connection, it might be remarked that there does not seem to be any standard practice in arriving at the actual cost of the coal cleaning operation. There seems to be a considerable difference of opinion as to whether the rock loss should be a direct charge to the cleaning operation or as to whether it should be charged back into the mining cost on the theory that it is the function of the mine to produce only saleable coal and that the mine operations should be penalized by the amount of impurities which it is necessary to take out in order to produce a product that is suitable for market conditions. From the standpoint of plant design it seems rather necessary to establish a certain definite value on the feed to the cleaning plant. In order to show the influence of the refuse loss on the final cost of operating a plant and therefore on the design we will assume that the feed has a value of $1.75 a ton and that the operating cost of the cleaning plant is 15 cents per ton of feed. On this basis, we then have a cost of $1.75 for the material and 15 cents for the operating cost or a total of $1.90. Supposing the feed to contain theoretically 7 percent of refuse and that one type of plant will give a recovery of 92 percent with approximately 10 percent of coal in the refuse and another a recovery of 89 percent with approximately 40 percent of coal in the refuse, then the final cost of the prepared product in the first case will be $2.07 a ton and in the second case $2.14 a ton or a difference of 7 cents a ton, which on a plant with any considerable tonnage, would certainly justify an increase of expenditure, if necessary, in order to give a more efficient result. It should be borne in mind that normally the function of a cleaning plant is not only to produce a clean coal but also to produce a clean refuse, but there are many plants now operating which are either producing a clean coal with a considerable loss in the refuse or else turning out a clean refuse at the expense of leaving a considerable part of the impurity in the cleaned product.

Quality and Use of Final Product

Naturally the desired quality of the cleaned coal is one of the most important factors in the selection of a plant as it is a relatively simple proposition to get a separation unit which will do a good job on taking out the heavy rock but leave the bone and the laminated product with the coal and it is this separation of the last part of the impurity, which closely approximates the specific gravity of the coal, which is the most difficult part of the problem. It is rather obvious to state that the nearer the operation must approach the theoretical results as shown on the specific gravity tests the more care must be taken in selecting the cleaning units and in the design of the plant as a whole.

The question of the use of the finished product is also an important factor. For metallurgical fuel it is rather common to sell coal on a guaranteed ash and sulphur basis with a premium and penalty clause and this also applies to a certain portion of the steam trade. The domestic coke manufacturers seem to place more emphasis on the freedom of extraneous impurities both on account of a greater loss in the breeze due to the coke breaking after quenching and also on account of the looks of the product.

To a certain extent a low fusion point of the ash may be an advantage in the case of the iron blast furnaces, but for the domestic trade they seem to prefer a coke with a high ash fusion point, say, from 2,600° to 2,700°. Here again it is important to have a thorough knowledge of the coal characteristics, for cleaning in some cases raises the fusion point of the cleaned product and in other cases it either has no effect or may possibly be lowered. For instance, in certain districts, the coal at a 1.40 specific gravity has a fusion point of 2,800° while the sink at 1.40 will fuse at 2,200°. I recently have seen some results from another field where the raw coal has a fusion point of 2,600° and the clean coal had a fusion point of 2,500°.

Capacity of Plant

The capacity of the plant has a certain influence on the design due to the fact that in a small tonnage plant it may not be economically possible to provide any retreating units and while this is bound to result in a lower efficiency at the same time, in many cases, the expense of retreatment would be more than the gain derived therefrom. In the larger plants, however, this is not the case as the efficiency of the process then becomes a more important factor in the cost and it is difficult to justify an inefficient large plant except in those cases where the percentage of refuse is extremely low.

It is in this matter of retreatment that the coal cleaning problem has much to learn from the experience of the metal concentrators as they have long since abandoned the idea that it was possible to make a clean finished product and a clean tailing on a single unit. This matter of retreatment is one that is of utmost importance where it is desired to produce a really clean coal of uniform quality, and, at the same time, a refuse reasonably free from separable coal. The retreating unit acts as a fly wheel in the operation of the plant and serves to take care of variations in the quality of the feed and in the operation of the primary units and acts to iron out these fluctuations so that a uniformity is maintained in both the quality of the coal and refuse. The question of producing a secondary fuel either to be sold as steam coal or used around the plant is one that is naturally dependent on the characteristics of the coal being treated but, whenever it can be done, it will be found to be of wonderful assistance in maintaining the efficiency of the plant at a high standard. In general, the higher the quality of primary product that is desired the more feasible it is to consider the production of secondary fuel, but, on the other hand, if a separation is being made to take out only the heaviest part of the rock and bone, then the cleaning up of the refuse may not produce a coal (*Continued on page* 566)

CLEANING COAL *at* NEILSON COLLIERY, SHAMOKIN COAL COMPANY*

By B. C. OSLER †

Mining Conditions Produce Wide Variation In Refuse In Mine-Run Coal—Entire Tonnage Under Three And One-Half Inch In Size Satisfactorily Cleaned—Saving In Operation Estimated At About Fifty Percent Of Material Costs And Eleven Percent Of Labor Cost Since The Installation Of The Present System

NEILSON COLLIERY, of the Shamokin Coal Company, is located at Shamokin, Pa., which is in the center ot the Western Middle Pennsylvania Anthracite Coal Field.

The coal beds being worked are all on steeply inclined pitches, and so far most of the coal mined has come from what are known as the overlying beds. Seven different beds are being worked. Due both to the character of the beds and the soft, friable slate roofs of some of these overlying beds, the refuse content of part of the mine-run has been very high. These mining conditions have tended to produce an extremely wide variation in the character of the mine-run being treated by the breaker.

B. C. Osler

The present Rheolaveur equipment was installed during the summer of 1927 and put in operation on September 1 of that year. It is designed for an output of 1,500 tons per eight-hour day and to wash all sizes from egg, which passes through a 3½-in. round mesh screen, down to and including No. 5 buckwheat, through a 3/64-in. round mesh screen and on 48 mesh. This last-mentioned size is recovered from the wash water by use of a Dorr bowl classifier. A flow sheet of the Neilson Breaker is shown on page 551.

The Rheolaveur washing equipment consists of a "sealed discharge plant" and a "free discharge plant." The completed sealed discharge plant will consist of a main washing launder and a rewash launder. The main washing launder is the only part of the sealed discharge plant that has so far been operated. This main launder is 48 in. wide, equipped with two Rheo boxes and a 24-in. extension launder with one Rheo box. The coal is fed into the sealed discharge plant at the top of the 48-in. launder. The refuse from the first Rheo box in the 48-in. launder is returned by an inclined elevator to the 24-in. extension launder and the refuse tapped off by the Rheo box on this launder is at present the final refuse from the plant.

The rewash launder which is being installed and is 90 percent completed consists of a 24-in. launder with two Rheo boxes. The feed for this rewash launder will be the material discharged by the 24-in. Rheo box on the main washing launder.

It will be noted from the flow sheet, Figure I, that the mine coal is given a preliminary screening operation, which removes all coal larger than 3½ in. or larger than egg size. The lump and steamboat sizes combined, i. e., the material larger than 4½ in., is treated on two picking tables, where the rock is removed and the coal and bone are delivered to No. 1 crusher rolls, where they are reduced to pass 4½ in. The original run-of-mine between 4½ and 3½ in. is sent direct to No. 2 rolls without any cleaning. The No. 2 rolls crush this material with the plus 3½ in. from the No. 1 rolls to pass 3½ in. The product from the No. 2 rolls with the original egg and smaller constitute the feed to the sealed discharge main washing launder.

The washed coal from the main washing launder of the sealed discharge plant passes to a double bank of 5-deck sizing screens, where the egg, stove, nut, pea and No. 1 buckwheat sizes are screened and sent directly to the pocket. The minus 5/16-in. round mesh material from these shakers is returned to the boot of the feed elevator of the free discharge plant. This elevator delivers the solids to the head of the free discharge plant, which is four launders high. The washed coal from the free discharge plant is delivered to a double bank of shaking screens four decks high over which is screened off rice or No. 2 buckwheat, 5/16 in. to 3/16 in. barley or No. 3 buckwheat, 3/16 in. to 3/32 in., and No. 2 barley or No. 4 buckwheat, 3/32 in. to 3/64 in. The wash water from these screens containing the minus 3/64-in. mesh material passes to a Dorr bowl classifier, where No. 3 barley or No. 5 buckwheat containing all the fines plus 48 mesh is recovered.

The make-up water for the plant is secured from the mine and consists of approximately 500 gallons per minute. It is put into the system through sprays on sizing screens. All the wash water in the system is returned to the boot of the free discharge plant feed elevator. The overflow from this boot is substantially free from plus 48-mesh solids. One-half of the overflow from the boot of this elevator is pumped to a tank at the top of the breaker, which supplies the sealed discharge plant. The other half goes to the Dorr thickener and after being clarified is pumped to a tank at the top of the breaker for the supply of shaker sprays, etc., and the operation of the free discharge and sealed discharge plants. Two 2,500 g.p.m. single-stage centrifugal pumps are used to handle the total circulating water requirements.

The operation of the Rheolaveur plant at Neilson Colliery has been most satis-

Neilson Breaker, Shamokin Coal Company

* Presented to Fifth Annual Convention, Practical Operating Men, Cincinnati, Ohio, May 9, 1928.

† General Superintendent, Shamokin Coal Co.

factory and dependable, and we feel that this is particularly true when the rate of feed and extreme variation in quality of the material being handled by the plant are taken into consideration.

A storage feed pocket at the head of the main washing launder was recommended by the engineers of the American Rheolaveur Corporation, but this pocket has not yet been constructed, so that the rate of feed to the Rheolaveur plant at times may be taken as the capacity of the main breaker elevator, which at its present speed delivers about 200 tons per hour.

After the plant was in operation for several days, we decided to dump the gangway rock cars along with the run-of-mine coal. These rock cars are loaded at the face of advancing coal gangways and usually contain varying quantities of coal. By running this gangway rock through the breaker, we were able to recover the coal which it contains and also secure a fairly economical way of handling and disposing of this material. As several cars of gangway rock might be dumped in succession, some doubt was expressed about its effect upon results, but no trouble has been experienced in the operation of the plant, nor has the quality of the washed coal or the amount of coal in the refuse been affected.

It must be kept in mind that we are operating the sealed discharge plant under the above conditions, both as to the rate and variation in the quality of feed, without the rewash launder. The coal in the refuse from the sealed discharge plant, determined by hand-picked tests, averages but slightly over 1 percent, while analyses of refuse from the free discharge plant show an average of over 65 percent ash.

The performance of the Rheolaveur system in the removal of refuse heavier than a certain predetermined specific gravity is, to all practical purposes, certain and positive. The practical application of the three principal forces controlling the separation of coal and refuse by the Rheolaveur system of washing, viz, the pitch of the washing launders, the height of barrages and the amount of upward current, explain the continuous, positive results obtained by this system of coal washing. The correct pitch of the washing launders has been very definitely determined by the Rheolaveur engineers. The correct height for barrages and the amount of upward current used can be readily determined in a very short time after the plant has been put in operation. The water for the upward currents is secured from a tank at a constant head and once adjusted can not vary. After the proper height of barrages and the proper amount of upward current have been determined, the plant will continue to operate with a minimum variation in either the quality of the washed coal or the amount of coal in the refuse.

The adjustment of the plant to deliver a certain quality of coal can be very easily made, and when once made there is but very little variation in the quality of the washed coal delivered.

Most engineers felt that the wide variation in the quality of feed at Neilson Colliery would be a considerable handicap to the successful operation of the plant, but this has not been the case. We know the plant adapts itself to the varying quality of feed, continuing all the time to produce a good quality of washed coal and refuse practically free of saleable coal.

The total recovery per mine car and the yield in domestic sizes has shown a satisfactory improvement since the Rheolaveur was put in operation.

There have been no delays in breaker operation since the Rheolaveur plant was started on September 1, 1927, to date of writing, due either to trouble with the operation of the plant or failure of any of the mechanical parts.

Our run-of-mine has varied. The mine producing the coal is just in the course of development. When the Rheo started, we had a certain percentage of coal from the different beds and as development from each new bed came along that percentage changed. In addition to that, we have also run through breaker some culm banks. It is impossible to give any definite figure as to just what did occur. If we had been securing all our output from one bed, or at a fixed percentage from different beds for the most of this operation, then some definite information could have been given.

There has also been a very considerable saving in the operating costs of the breaker since the Rheolaveur was installed, not only as to costs per ton, but in the total monthly outlay in dollars. The average saving in dollars for the first six months of Rheolaveur operation compared with the prior six months of operation has amounted to 50 percent of the prior material costs and 11 percent of the prior labor costs. The cost per ton would show a greater reduction, as the average production for the first six months of Rheolaveur operation was 19 percent greater than during the previous six months. Furthermore, the Rheolaveur installation cleaned the entire tonnage from 3½ in. to 0 in size, whereas the previous system in use cleaned only the coal from 3½ to 5/16 in., which constituted, roughly, half of the tonnage produced.

JOHN GRIFFEN, of the *American Rheolaveur Corporation*, in discussing this paper said: "Before touching directly on this particular paper, I want to quote from a report of the Coal Cleaning Conference that was held in Edinburg on July 7, 1927, from a paper on 'A Comparison of Processes for the Cleaning of Coal,' presented by W. R. Chapman and R. V. Wheeler, of the Department of Fuel Technology of the University of Sheffield, England. What I will quote deals particularly with the question which was touched upon by Mr. Morrow on the ability of various coal cleaning processes to properly separate materials of intermediate gravity, between the purest coal and the pure refuse. It is essential that separation of such intermediate gravity material may be controlled so as to produce the qualities of coal required for various market requirements.

"'All modern coal cleaning processes, under proper working conditions, can effect a satisfactory separation between "pure" coal and "pure" dirt. They vary, however, in their ability to deal accurately with interstratified particles of intermediate density, and, consequently, in the ease with which products of different specified qualities can be obtained. In selecting a process for cleaning coal, it is frequently desirable to choose one which enables the "cleanest" of the interstratified particles to be collected with the coal and the "dirtiest" to be discarded with the refuse, or, alternatively, one which allows any predetermined proportion of the interstratified particles to be retained in the clean coal fraction, the remainder passing into the refuse. By such a choice the best possible advantage is taken of the particles of an intermediate character.'

"Then the authors set up a case to bring out this point and indicate what it means in dollars and cents. 'Suppose that the results of a float and sink analysis of a given coal are as follows: Seventy-five percent of raw coal floating on 1.4 gravity, with an ash of 6 percent, 10 percent with a gravity between 1.4 and 1.5 and an ash of 15 percent, 10 percent between 1.5 and 1.6 gravity, at 30 percent ash and a sink in 1.6 gravity of 5 percent, with an ash of 80 percent. In other words, 5 percent of pure refuse making an ash in the raw coal of 13 percent.

"'If all the material floating in a liquid of 1.4 is included in the clean coal and all the material sinking in a liquid of 1.6 passes into the refuse, the yield and quality of the clean coal will depend upon the course taken by the intermediate material. Consider the results that could be yielded by two washers, one, "A," unable to discriminate between particles of 1.4 to 1.5 and particles of 1.5 to 1.6, and the other, "B," capable of doing so. If the two washers be set to recover 85 percent of the raw coal as clean coal, the recovery will be, in the case of "A," 75 percent floating in 1.4 gravity at 6 percent ash, one-half of the material of gravity of 1.4 to 1.5, or 5 percent with 15 percent ash, and one-half of the material of density of 1.5 to 1.6 with an ash of 30 percent, or 7.94 percent ash in the washed coal.'

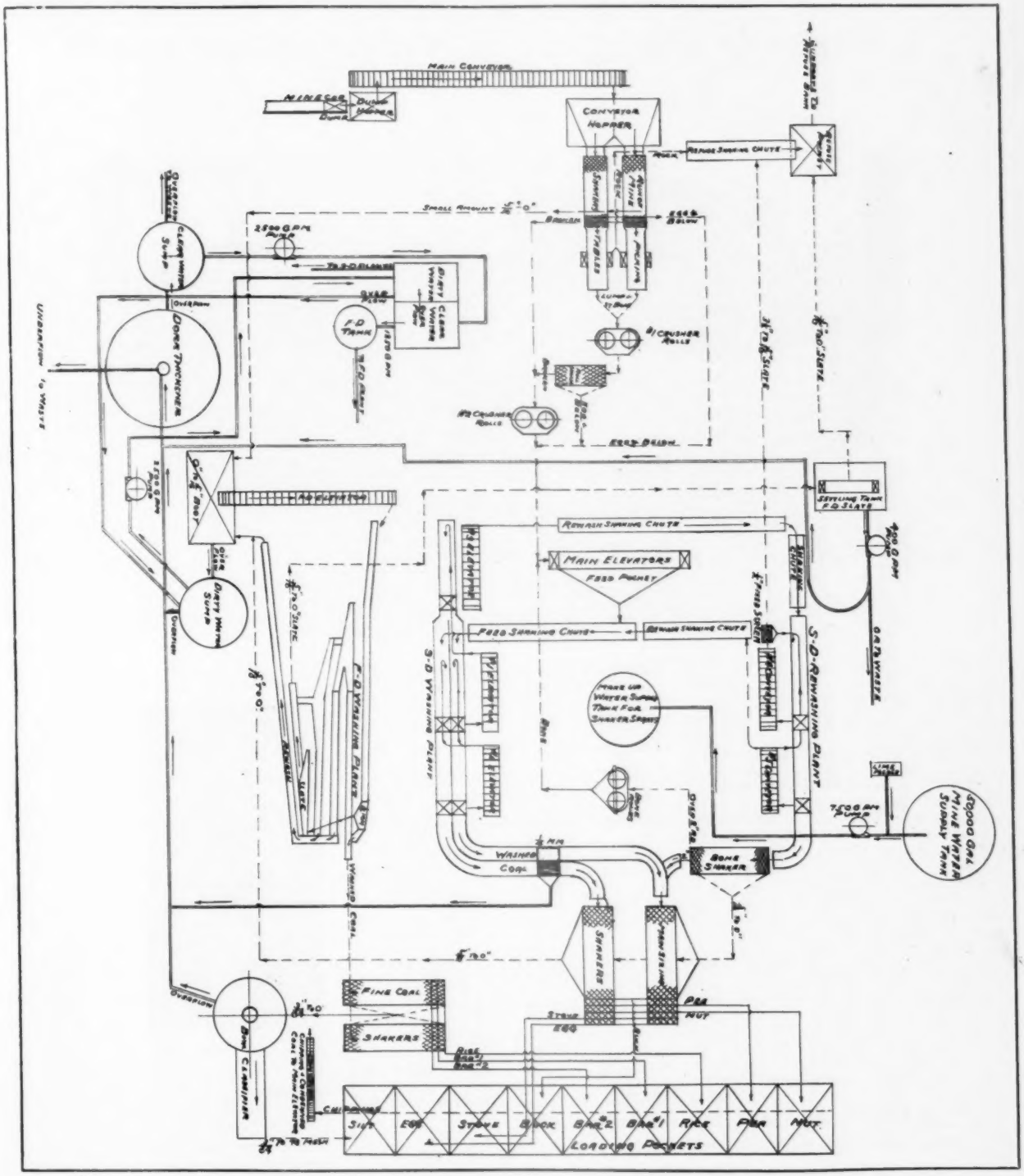
"In the case of washer 'B,' which is capable of discriminating between 1.4 and 1.5 gravity material, and 1.5 and 1.6 gravity material we have 75 percent recovery, of 1.4 float material at 6 percent ash, and all the 1.4 to 1.5 gravity material at 15 percent ash, giving the same over-all recovery of 85 percent with an ash of 7 percent. The washed coal from washer 'B' would be nearly 1 percent less ash than that from washer 'A.'

"If, on the other hand, the washers are set to produce the same quality of washed coal, the authors' calculations show the increased recovery which washer 'B' can make. On the basis of 7½ percent ash in the washed coal, 4.2 percent additional coal is recovered by washer 'B.' For a plant which has a capacity of 100 tons an hour operating eight hours per day, and 300 days during the year, that would amount to an additional saving of 10,000 tons of coal per year.

"This is, of course, a hypothetical case. There isn't any washing equipment which will do exactly what has been set up for washer 'B.' But there are, however, some coal washers which approach, theoretically, perfect results much more closely than do others.

"I might say that English publications on coal during the last few years have contained a very great many reports of interesting, authoritative, and painstaking studies and research, and they are well worth the consideration of American coal cleaning men.

"In this paper by Professors Chapman and Wheeler the various processes in use in England are discussed in very considerable detail. In referring to actual operating results in going plants in England, the following is said regarding the Rheolaveur process, in relation to this question of handling intermediate gravity



material: 'The high efficiency of the Rheolaveur, as regards the recovery of particles of an intermediate character, makes it probably the most efficient washer in existence for a coal rich in such material.'

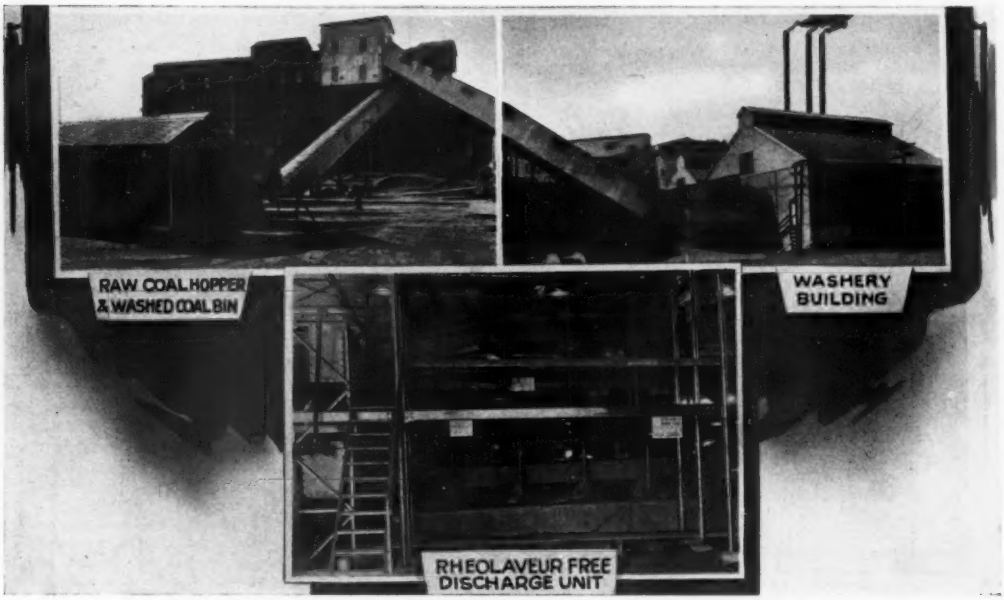
"All the above has a bearing on the Neilson Colliery operation described in Mr. Osler's paper, because, in addition to the fairly large amount of refuse in the mine coal, there is a quite high proportion of intermediate gravity material which lies, roughly, between 1.65 and 1.9.

"In order to produce a marketable material with high recovery it is necessary on the larger sizes to include material up to 1.75 gravity, and on the smaller sizes materials up to 1.80 or 1.85 gravity, while rejecting material of only slightly higher gravity.

"The completed plant will make it easier to deal with this situation and increase the recovery, because the rewash launder referred to provides for the separation of the material of about 1.75 to 1.9 gravity from the pure refuse before it is discharged to the bank. Crushing of this 1.75 to 1.90 gravity material to a smaller size will allow of its being rewashed and thus increase the recovery."

COAL WASHING
at AMERICAN SMELTING & REFINING COMPANY PLANT*

By G. P. BARTHOLOMEW †



First Free Discharge Rheolaveur Operation In United States—Character Of Coal—Washability Tests—Ash Reduced From 16 Percent To Less Than 10 Percent—Operating Performances Showing Capacities, Recovery And Ash Reduction — Labor Required And Power Consumed

THE Cokedale Washery of the American Smelting & Refining Company, which washes the coal from their Bon Carbo mine, is located at Cokedale, Colo., adjacent to their beehive coke oven plant. The entire output of the washery is utilized for the production of coke, which in turn is largely shipped to the various smelters of the American Smelting & Refining Company.

The Bon Carbo mine is in the Mesa Region north of the Raton Field and is part of the Trinidad Coal Field. One seam only is being mined and, as the seam is roughly horizontal, the room and pillar system is used.

The geologic age of the coal is lower Cretaceous, which would normally give a sub-bituminous or lignitic coal, but, owing to volcanic action in the region, a bituminous coal of excellent coking quality is found. There is evidence that after the seam was deposited and fairly well consolidated, violent disturbances took place which resulted in pulverizing and mixing the coal and shale strata, which were later further consolidated and further metamorphosed by volcanic heat.

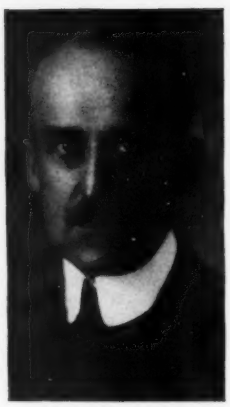
As a result of the above, the shale, bone and coal are so finely banded that it is necessary to crush the mine coal to minus 5/16 in. (8mm.) in order that washing will produce a sufficiently low ash coal with a high recovery.

By careful mining and loading, the ash in the mine coal is kept at from 15 to 16 percent, while sulphur varies from .6 to .8 percent and thus offers no problem in washing. The volatile matter in pure coal is about 33 percent.

The mine cars are delivered to a tipple with screens and picking table, where at times the larger coal is cleaned by hand and sent to the domestic market. The balance of the coal is loaded into railroad cars for delivery to the washing plant at Cokedale, 8 miles distant.

THE WASHING PLANT

The general arrangement for unloading, storing, washing and handling of washed coal and refuse is shown in the flow sheet, Figure 1. The railroad cars deliver their contents by gravity into the track hopper, under which is located a two-roll toothed Jeffrey crusher, which delivers a product minus 2½ in. to raw coal conveyor delivering to the storage bins on the hillside above the washing plant. These bins serve as regulating and mixing bins. Conveyors below these bins, with a capacity of 140 tons per hour, receive raw coal through feeders for delivery to the washing plant. On its way to the washing plant the raw coal, after removal of tramp iron by a magnetic pulley, is delivered to an American ring crusher, where it is crushed to pass 5/16 in. The crushed coal is delivered by a feeding conveyor equipped with a weightometer to a feed hopper from which it is discharged through a rotary table feeder to the three free discharge Rheolaveur washing units operating in parallel.



G. P. Bartholomew

The three Rheolaveur free discharge washing units are identical in general arrangement and operation and are each four launders high. The disposition of launders and boxes and application of water for washing is shown in Figure 2. Raw feed is delivered at the upper end of the top launders and washed coal is collected at the ends of launders 1, 2 and 3 and delivered to the washed coal dewatering conveyor equipped with ¼ m/m wedge wire screen. This conveyor delivers to the top of the washed coal storage bins, where distributing conveyors deposit the

* Presented to 5th Annual Convention, Practical Operating Men, Cincinnati, Ohio, May 9, 1928.

† General Manager, Coal Mining Department, American Smelting & Refining Company.

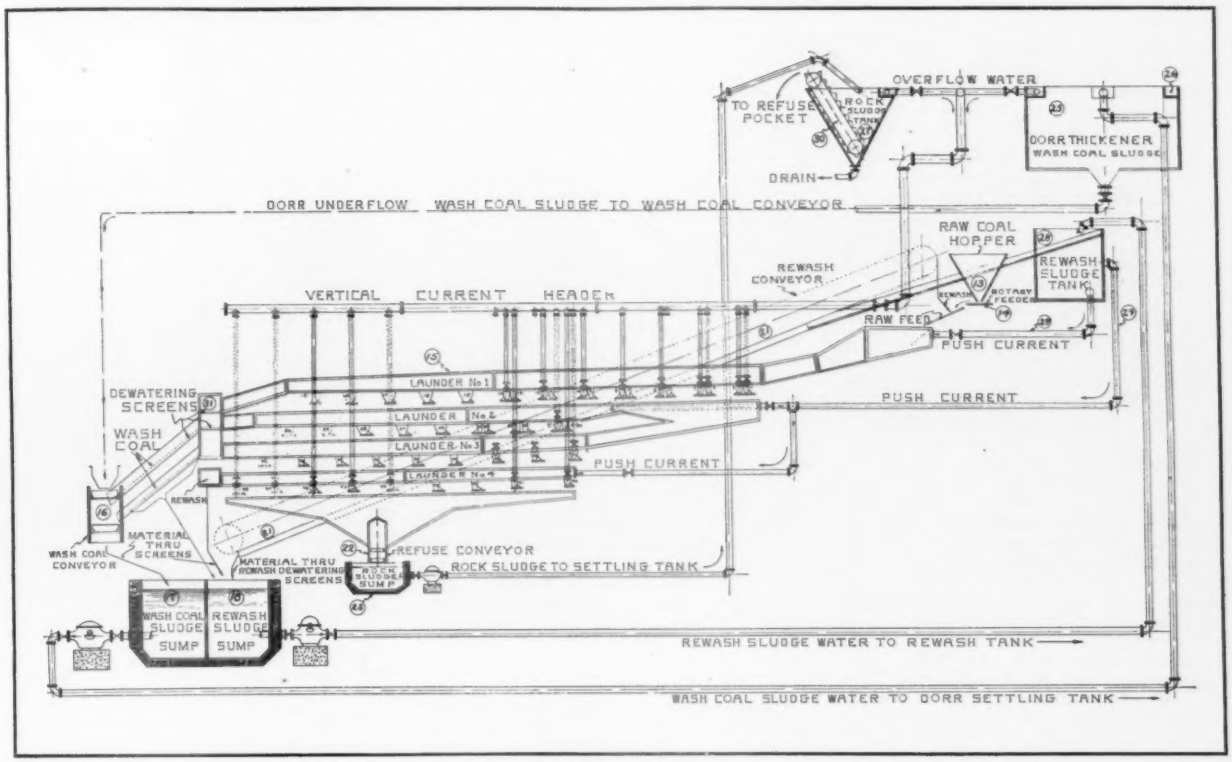


Figure 2

washed coal into various bins from which it is drawn for delivery to the coke ovens. The water and minus ¼ m/m washed coal solids passing through the wedge wire screen on the washed coal conveyor gravitate to the washed coal sludge sump from which it is pumped to a 70 ft. Dorr thickener located on the hillside above the washing plant. The coal sludge discharged from the bottom of the thickener with from 50 to 60 percent by weight of solids flows by gravity to the washed coal conveyor and is there deposited on top of the already dewatered washed coal which acts as a filter.

Rewash or regulating material is discharged from the lower end of the No. 4 launders and delivered to a rewash conveyor also equipped with ¼ m/m wedge wire screen for dewatering. This conveyor delivers the plus ¼ m/m rewash material to the point of raw feed to the three washing units from which it returns through the washing plant. The water and fines passing the wedge wire screen on this conveyor gravitate to the rewash sludge sump and are pumped to a tank above the washing units for use as push current in these units.

Refuse is discharged by the Rheo boxes on the No. 4 launders to a conveyor equipped with ¼ m/m wedge wire screen, which delivers to a refuse bin from which an aerial tramway delivers to the refuse bank. The water and fine solids drained from the refuse are pumped to the rock sludge tank equipped with a dewatering elevator which delivers the fine waste to the refuse bin.

The partially clarified water overflowing the thickener and the rock sludge tank returns to the washing units by gravity and is used as upward current in the Rheo boxes where required.

It is probably generally understood that the Rheolaveur system of washing utilizes the classifying effect of a flowing stream of water and the supplementary classification obtained by the Rheo boxes which operate as hydraulic classifiers. This results in the bedding of the heavy gravity material at the top of the first launder and the Rheo boxes extract this refuse progressively as material flows down the launder. The Rheo boxes on the upper launders are oper-

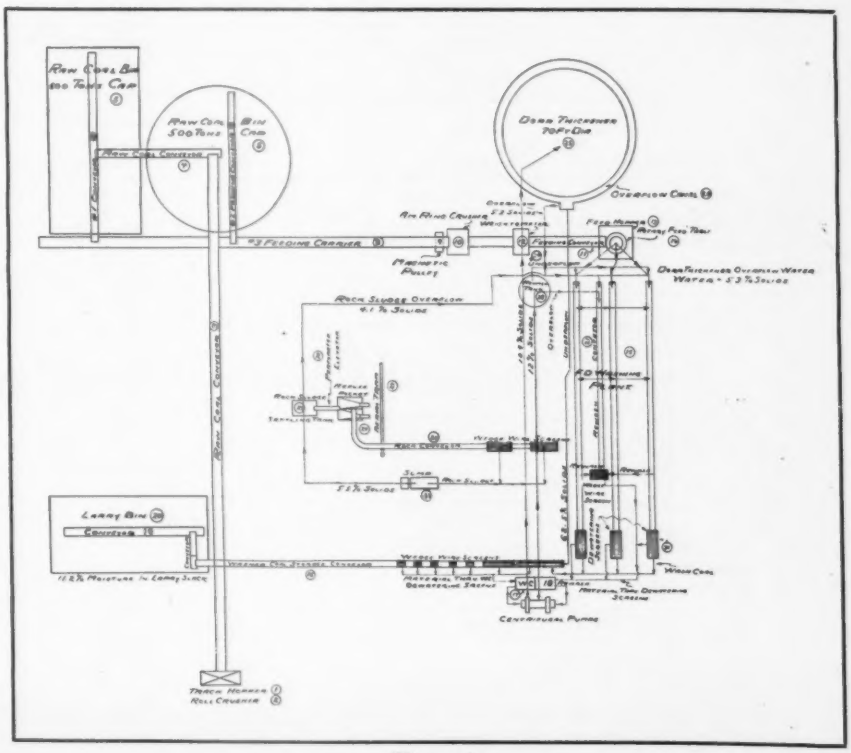


Figure 1

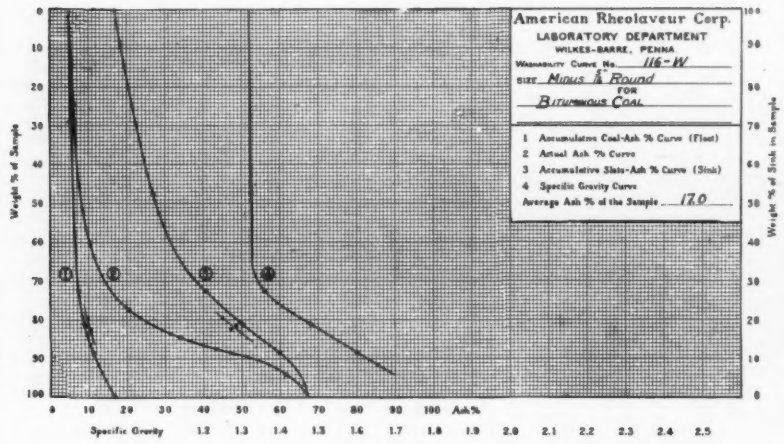


Figure 3

ated to remove completely the refuse material and the lower launders, in this case, the fourth launder, are used to re-wash the refuse extracted from the upper launders, so that the final refuse discharged from the plant shall be free of marketable coal. The material in the fourth launder which is not drawn through its Rheo boxes discharges from the end of this launder and is used as regulating material, acting very much as a fly-wheel in producing uniform results as to quality of both washed coal and refuse, even though the feed varies in quality and quantity.

The installation and early operation of this plant have previously been covered in two papers.* The first washing unit was put in operation in August, 1926, followed by the second unit in March, 1927, and the third unit in September, 1927.

* Metallurgical Coal Washing Plant of American Smelting & Refining Co. at Cokedale, Colo., by M. Walle and G. V. Woody, Mining Congress Journal March, 1927. Washing Bituminous Coal With the Rheolaveur Process at Cokedale, by Charles A. Spahr. Proceedings, The Rocky Mountain Coal Mining Institute, 1927, Vol. II, p. 49.

TABLE I—OPERATING RESULTS WITH AVERAGE 17 PERCENT ASH FEED

1927	Figured Recovery Percent	Washed Coal Ash Percent Actual	Washed Coal Ash Percent Theoretical	Refuse Ash Percent Actual	Refuse Ash Percent Theoretical	Actual Recovery
January 16 to 31	82.1	10.20	9.0	48.1	51.1	....
February 1 to 15	82.6	10.10	9.1	49.7	51.9	....
February 16 to 28	83.2	10.15	9.4	51.2	53.0	....
March 1 to 31	83.2	10.17	9.4	50.8	53.0	81.8%
July 1 to 31	82.0	10.30	9.8	49.2	51.0	82.6%

TABLE II—COMPARISON OF COKEDALE RHEOLAVEUR FEED

	February, 1927 — High Ash Each %Wt.	High Ash Fraction %Ash	High Ash Cumulative %Wt.	High Ash Cumulative %Ash	Low Ash Each %Wt.	Low Ash Fraction %Ash	Low Ash Cumulative %Wt.	Low Ash Cumulative %Ash	March, 1928 — Low Ash Each %Wt.	Low Ash Fraction %Ash	Low Ash Cumulative %Wt.	Low Ash Cumulative %Ash
Float 1.35, Coal...	52.0	6.0	52.0	6.0	65.5	6.0	65.5	6.0	65.4	6.0	65.4	6.0
Sink 1.35 and Float 1.54, Bone..	27.0	16.4	76.0	9.5	19.5	19.7	85.0	9.2	22.4	18.5	87.8	9.2
Sink 1.54, Refuse.	21.0	57.9	100.0	19.5	15.0	53.5	100.0	15.8	12.2	53.5	100.00	14.6
Raw Coal.....	100.0	19.5			100.00	15.8			100.0	14.6		

TABLE III—OPERATING RESULTS WITH AVERAGE 15.8% ASH FEED

1928	Recovery	Washed Coal Ash % Actual	Washed Coal Ash % Theoretical	Refuse Ash % Actual	Refuse Ash % Theoretical
February	87.1%	10.4	10.1	52.3	57.1
March	85.8%	9.8	9.6	52.1	54.8
April 2	85.3%	9.6	9.4	51.7	54.0

TABLE IV—OPERATING PERFORMANCE

	February 1928	March 1928	April 2, 1928
Tons raw coal charged to washer	19,945	17,364	
Hours washer worked, actual running time	191.5	136.08	
Average tons raw coal washed per hour	104.1	127.6	136.0
Same per hour per unit	34.6	42.5	44.5
Percent ash in average feed	16.8	15.5	14.4
Percent ash in average washed coal	10.4	9.8	9.6
Percent average ash refuse	52.3	52.1	51.7
Per cent figured recovery	84.7	86.5	88.5
Percent average ash coke	15.2	15.1	
Kw. H per ton washed coal, including crushing and conveying	2.93	2.37	
Kw. H. per ton feed coal, including crushing and conveying	2.37	1.97	

Washability Studies on Raw Material

Washability studies on a sample of feed coal submitted before the plant was designed indicated a recovery of 78 percent of washed coal analyzing 10.8 percent ash with a refuse analyzing 48 percent ash and a capacity of 40 tons per hour feed per unit, or 120 tons per hour for the entire installation. Operating results, which will be given later in the paper, show that the plant now is exceeding these predictions in all respects.

During the early months of operation of this plant considerable experimenting was carried on to determine details of operation which would produce the most efficient and economical results. The necessity for crushing the raw material to pass 5/16 in. naturally resulted in the production of considerable dust and fines which introduced difficulties in the washing operation. Originally the minus 5/16 in. material in the raw coal was screened out and by-passed the ring crusher, only the 2½ in. by 5/16 in. material being crushed. Tests conducted by the washery force developed that elimination of this screening operation and the use of slightly larger bar spacings in the crusher resulted in a material reduction in fines. The first step was to eliminate prescreening and later the larger bar spacings were adopted. The progressive improvement obtained is shown by the following size tests:

	Sept., 1926 Percent	Apr., 1927 Percent	Mar., 1928 Percent
Plus 5/16 in.....	.2	.4	.6
Minus 48 mesh...	15.5	12.5	10.0

This improvement in crushing practice reduced the amount of minus 48-mesh material in the feed to the point which had been anticipated from the original washability study.

During the first year of operation the quality of the raw material as to ash was quite variable, averaging approximately 17.5 percent with average daily samples varying from a minimum of 16 percent to a maximum of 21 percent ash. The washability characteristics of an average feed coal during this period are given in Figure 3.

Results Obtained

Due to the high and variable ash content of raw material, it was found that the capacity of the units was only approximately 30 tons per hour with the very efficient washing results demanded. Table I shows the accomplishment of the washing plant during the first seven months of 1927. Recoveries have been recalculated to an average of 17 percent ash feed in order that the data can be compared with the washability curves on raw material shown in Figure 3.

It will be noted that the agreement between the actual ash in the washed coal and refuse and the theoretical ash indicated by a perfect separation show close agreement in the later months. It is also of interest to note how close the theoretical recoveries are to the actual recoveries determined by weighing feed and washed coal.

Operation With Cleaner Raw Material

Recently we have been able to establish better control of the quality of coal loaded into the mine car, which has eliminated considerable of the coarse high ash refuse from the raw material to the

Our present most perplexing problem is the handling of the wet sludge which is discharged on top of the coarser washed coal. The mixture of the two, due to the churning or tumbling action, resulting from the travel of the scraper on the inclined conveyor, limits the capacity between the flights to a more or less water level surface. This condition varies, of course, with the quantity of sludge added and its moisture content. The logical solution is, obviously, dryer sludge—a result not difficult of accomplishment.

As this was the first Free Discharge Rheolaveur plant installed in the United States, its successful operation was not, of course, a matter of immediate accomplishment, but involved a careful and constant study of the problems to be overcome in the preparation of this particular coal. The ready resourcefulness on the part of Messrs. Bubb, General Superintendent, and Spahr, Washer Foreman, in determining the proper adjustments to make as these problems arose, has resulted in their entire elimination, to all practical purposes, and it is our opinion that no washing system could be more simple and uniform in its operation, nor lend itself more readily to regulation and adjustment, to meet conditions as they change—as change they do.

washery. As an illustration, the washery feed for the month of March, 1928, shows a variation in ash on average daily samples from a maximum of 16.1 percent to a minimum of 15.1 percent with an average of 15.5 percent for the entire month. The change in quality of washery feed resulting from this improved mining practice is perhaps best shown by the float and sink tests given in Table II.

This data clearly indicates that the greatest change occurred in the elimination of heavy gravity high-ash refuse—not only does the amount of sink in 1.54 specific gravity decrease but also its ash content is lower. On the contrary, the proportion of bone to refuse in the washery feed has increased.

Due to the greater regularity in feed quality, the washing problem has been simplified in some respects. On the other hand, the increased proportion of bone makes it impossible to maintain the same high ash refuse.

Figure 4 shows washability curves on raw material of this improved quality with 15.8 percent ash. On this curve operating results for several months have been plotted to show the close agreement between actual plant performance and theoretical separations. In Table III this comparison is given in tabulated form.

It will be noted that the actual washed coal ash is within 0.3 percent of the ash of the true float at a like recovery. This indicates that the washing plant during the later period is showing a higher efficiency.

Operating performance of the Cokedale washery for the months of February and March is given in Table IV.

So far in April the ash in the washed coal has been under 10 percent and in the coke well under 15 percent.

It will be noted that in February, 1928, the capacity per unit had increased to 34.6 tons per hour, while in March it had further increased to 42.5 tons per hour. We are confident that with raw coal running not over 16 percent ash, we can maintain the 40 tons per hour capacity rate for our particular coal without difficulty and with excellent washing efficiency.

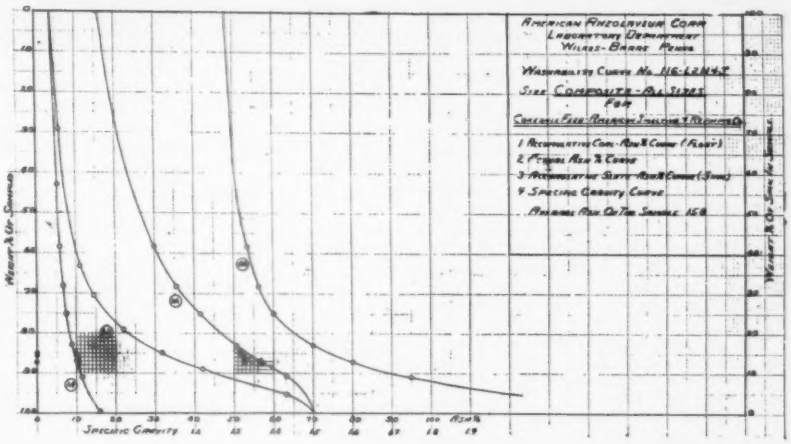


Figure 4

Cost of Washing

With the washery operating at full capacity our costs per ton of washed coal are well under 20 cents, including direct operating expenses, depreciation, overhead and royalty. Actual repairs on the washing plant, excluding any changes to improve operation, have been negligible.

Labor

The force to operate the present installation consists of two men attending the Rheo launders, one man taking care of the Dorr Thickener and the crushing plant, and one man for the distribution of washed coal, refuse, etc.

General

We are not prepared to say what the capacity of this plant may ultimately be, but as this capacity is limited not so much by the ability of the launders to deliver coal of satisfactory quality and quantity, as it is by the washed-coal conveyor to remove the finished product, we have no doubt that, with improvements in the operation of the latter unit, it should be possible to wash satisfactorily at least 50 tons per hour in each unit.

Efficiencies of Coal Washers

In discussing Mr. Bartholomew's paper, ***J. R. CAMPBELL**, American Rheolaveur Corporation*, said: "I wish to take up only one phase of coal washing, and that is the question of "Efficiencies of Coal Washers," which must be a vital factor in the coal washing program of the future, if it is to be successfully carried out and yield the greatest returns to the coal operator as an investment. In illustrating my points I have used data on the Cokedale plant furnished by Mr. Bartholomew. It is not my desire to step on anybody's toes in this discussion when I use the data that is available with which I have been familiar, in some cases, for a good many years. I am making an honest effort in this 'coal washing game' to bring about better conditions for the

'good of the order,' and if I don't have a 'horse I can ride or a pipe I can smoke,' I want to find it out. I will welcome helpful suggestions in formulating a standard for coal washer efficiencies by which we can reach logical conclusions.

"When I came to the Connellsville coke region in 1904, 40,000 beehive ovens were wasting valuable by-products into the air—an economic loss. About the same time Henry Koppers was pleading with the large coal companies to install his by-product coke oven for the manufacture of metallurgical coke. Koppers saw his dream realized. The wasteful beehive coke oven has been relegated to the limbo of the past. It was inexpensive in first cost—only $1,000 per oven, against $40,000 for a by-product oven, but the losses were tremendous as now known. The by-products, once in the air, were gone forever. From a technical standpoint, the beehive coke oven always was an 'economic crime,' even though the time apparently was not propitious for the advent of the by-product coke oven 25 years ago.

"Nowadays, I feel pretty much the same toward the inefficient coal washer as Koppers did towards the wasteful beehive coke oven. We often talked about the situation, and his language was strong and vehement—hardly fit for print. I hope I will be as successful in providing the stimulii for coal operators and steel men to install efficient coal-cleaning equipment as Koppers and Semet-Solvay were in getting them to adopt by-product coke ovens. After all, why should not the coal-cleaning equipment be just as efficient as the by-product coke oven or the blast furnace? The three are closely linked and should function together. It is to be regretted that the coal washer has been the weakest link in the chain in the past, and in some cases it has been of doubtful value. It is still the 'weak sister' in a good many cases seen among the going plants where the losses are tremendous and the 'unknown' costs high. Such a condition can not obtain much longer—the inefficient coal washer must go the way of the wasteful beehive coke oven. A better understanding of cost and performance of coal washers by coal operators and steel men will be a factor in bringing this about. Manufacturers can no longer foist inferior wares on their clientelle—when dollars and cents get to vieing with each other in a battle for supremacy. The ultimate answer is cost and performance.

"We are endeavoring to bring about a better understanding of the coal-washing problem, hence this detailed excursion into efficiencies.*

"In the papers referred to I have shown how washability studies are set-up based on 'sink and floats' data, which is rapidly becoming the universal language both on 'washability' and 'performance.' A few 'rule of thumb' and 'practical test' men still can be found, but they, too, must eventually give way to good theory and its practical application in coal washing.

"There are two fundamental methods of determining the efficiency of a coal washer:

(a) "Sink and float" tests on the washer products at the washing† gravity (no dual gravity).

(b) Chemical analysis of the washer products.

"The 'sink' and 'float' data may be formulated as follows:

DRAKELEY'S FORMULAS

$$\textit{Qualitative Efficiency} = 100 \times \frac{(\text{Washed coal float} - \text{feed coal float})}{100 - \text{feed coal float}}$$

$$\textit{Quantitative Efficiency} = 100 \times \frac{\text{Feed coal float} - \dfrac{\%\ \text{refuse} \times \text{refuse float}}{100}}{\text{Feed coal float}}$$

$$\textit{Bank Loss} = 100\% - \text{quantitative efficiency}$$

"There is some objection to the old Drakeley formulas. In the qualitative efficiency formula the percent float in the washed coal is expressed in terms of washed coal. Properly it should be expressed in terms of feed coal. Likewise, the quantitative efficiency show the recovery of the good coal in the feed coal—not the recovery of feed coal as seems logical.

"In view of this I present the following modified Drakeley's formulas, as worked out in conjunction with Mr. M. P. Walle, research engineer, American Rheolaveur Corporation, Wilkes-Barre, Pa.:

MODIFIED DRAKELEY'S FORMULAS

$$\textit{Qualitative Efficiency} = 100 \times \frac{\%\ \text{Sink in feed coal} - (100 - \%\ \text{refuse}) \times \%\ \text{sink in washed coal}}{\%\ \text{Sink in feed coal}}$$

$$\textit{Quantitative Efficiency} = 100 - \frac{(\%\ \text{refuse} \times \%\ \text{refuse float})}{100}$$

$$\text{Bank loss} = \frac{(\%\ \text{refuse} \times \text{refuse float})}{100}$$

or 100%—Quantitative efficiency

Note—All formulas expressed in terms of feed.

"I maintain that quality and quantity can be obtained simultaneously—80 to 85 percent qualitative efficiency and 99½ percent quantitttive efficiency with the efficient coal washer of today with the above formulas if the percent reject is within reasonable limits, say, 10 percent. Sometimes the latter is a very important factor in the problem.

"Instead of formulating the efficiency of a washer from 'sink and floats' it is sometimes convenient to report the percent sink in washed coal and the percent float in refuse. We then set up a standard for the washery products which is the equivalent of the foregoing standards—approximately 2 percent sink in washed coal and 5 percent float in refuse (all sizes) at the washing gravity. An operator can 'fool himself' quite a bit by using a lower gravity for testing the refuse, i. e., the dual gravity system.

"The second method of evaluating the performance of a coal washer is by chemical analysis which, as always, must be the final arbiter. After the standard from 'sink and float' is set up and the relations between them and chemical analysis established there is no difficulty in keeping a measure of the performance of the washer by analysis with an occasional 'sink and float' test.

"An efficient washing job (dry or wet) should show to within one-half to three-fourths percent of the theoretical washed coal ash and to within 3 to 3½ percent of the theoretical refuse ash as established by the washability curves, depending somewhat upon the character of the coal. This may be formulated as follows:

Washed coal=a+0.5 percent
Refuse =b—3.5 percent

"As to practical sulphur results, my experience is that in wet washing the float and sink test is very nearly duplicated in practice—no increment in the washed coal sulphur. In many cases a factor may be used with impunity. Then, if the float shows 1.50 percent sulphur, the practical sulphur is 1.50×.9=1.35 percent.

"A convenient form for keeping sink and float data and chemical analysis is as shown in the accompanying blank for chemical test data. (Page 559.)

"Some efficiencies by the two methods are shown in the tables A and B.

"In this method clean coal is a+.8 percent ash and refuse is b—3.4 percent ash where a=9 percent ash and b=55 percent ash. In this case the washing is efficiently done down to 48 mesh. In each illustration it will be noted that both quality and quantity are obtained in one operation as it should be. *Quality and recovery* should be the slogan in coal washing, coupled with costs, naturally.

TESTS ON WASHERY REFUSE

"I have examined many washery refuse dumps. A few typical examinations are shown to indicate their character and the amount of good coal lost—the 'bank loss' to be specific.

"In the refuse test (Table C) washing gravity may be taken at 1.46. On this basis there is approximately 40 percent float (good coal) in sizes 2½-in. x 0, indicating a bank loss of 2 percent, with a total reject of 5 percent. This amounts to 4 cents per ton with $2 coal, and on a 2,000-ton plant $40 per day, or $12,000 per 300-day year=the interest at 5 percent on $240,000. A 10 percent reject doubles these figures.

* See "Coal Washing—Some Factors in the Problem," Eastern States Blast Furnace & Coke Oven Association, Pittsburgh, Pa., June 4, 1927. "Cleaning Bituminous Coal," American Institute of Mining & Metallurgical Engineers, New York, N. Y., February 20, 1928.

† The washing gravity is established from the curves of the washability study.

TABLE A—SINK AND FLOAT METHOD

Sample Distribution by wgt.		Main feed 100%			Washed coal 91%			Refuse 9%		
Size of Coal	Size screen inches (round hole)	Percent Ash	Percent Float 1.95	Percent Sink 1.95	Percent Ash	Percent Float 1.95	Percent Sink 1.95	Percent Ash	Percent Float 1.95	Percent Sink 1.95
Egg	3 7/16 x 2½	18.81	89.0	11.0	6.5	100.00	0.00	75.5	1.21	98.79
Stove	2½ x 1 9/16	17.70	88.0	12.0	6.5	99.75	0.25	84.2	1.41	98.58
Nut	1 9/16x1 1/16	15.65	90.0	10.0	7.6	99.31	0.69	80.2	0.52	99.48
Pea	1 1/16 x 0/16	14.40	91.0	9.0	7.2	98.69	1.31	80.6	3.09	96.91
Buckwheat	9/16 x 5/16	14.40	92.5	7.5	10.4	96.76	3.24	82.8	2.79	97.21
Rice	5/16 x 3/16	13.70	93.0	7.0	10.1	96.36	3.64	81.9	3.40	94.60
Barley	3/16 x 3/64	15.90	90.0	10.0	12.9	93.64	6.36	61.4	21.50	78.50
Composite		16.12	90.0	10.0	7.68	98.78	1.22	80.2	1.76	98.24

Qualitative efficiency = 87.8%
Quantitative efficiency = 99.8
Bank loss = .2 good coal
Washing 3 7/16" x 3/64" together and afterward sized

SULPHUR TEST

Size ⅜"—48 mesh (Composite)
Curve No. 212-ES

Specific gravity	Wt., Pet.	Sulphur, Pet.
Float 1.300	18.1	0.84
Sink 1.300	16.7	1.38
Sink 1.380	16.4	2.30
Sink 1.575	14.1	3.53
Sink 1.800	12.2	4.66
Sink 2.000	22.6	13.08
Total	100.1	
Average		4.78

"In the above refuse test the percentage of float (good coal) at the washing gravity (1.40) is about the same as in the dry table test. In this case, however, the raw coal showed 11 percent ash and 2 percent sulphur, which was reduced to 6½ percent ash and .9 percent sulphur—a high quality washed product but entailing a high percent of reject (about 20 percent) and a refuse rich in values. The 'bank loss' is approximately 8 percent, which amounts to 16 cents per ton at $2 coal. On a 1,000-ton plant the value of the 'bank loss' is $160 per day, or $48,000 per 300-day year=the interest at 5 percent on $960,000.

"In the above example the cost of washing is high from a 'conversion cost' standpoint alone—50 cents per ton with coal at $2. The washed coal should demand a premium in order to compete.

TABLE E—FLOTATION PROCESS

Feed Coal—100% (Composite 3½ x 0)

Sp. Gr.	Pct. sink in feed coal
1.90	9.66
1.80	14.36
1.70	20.36
1.60	32.43
1.50	44.38

WASHED COAL—85.2 PERCENT

Composite 3½" x 5/16", 5/16" x 0" bypassed the washer in accordance with standard practice
Washing gravity—1.80

Sp. Gr.	Pct. sink in washed coal
1.80	2.81

Refuse—14.8 percent

Sp. Gr.	Pct. float in refuse
1.90	34.64
1.80	19.05
1.70	4 09
1.60	0.65

Efficiencies at washing gravity, 1.80.

By Drakeley's formulas

	Pct.
Qualitative efficiency	80.4
Quantitative efficiency	96.7
Bank loss	3.3

"It will be noted that while this is considered a 'sink' and 'float' process, there is 'sink' in washed coal and 'float' in refuse like any other process, showing that it acts mechanically in simulating the washing gravity, or is 'off gravity' at times, just like any other washer.

HYDRAULIC CLASSIFIER OR SEPARATOR

"I have been following this type of coal washer with considerable interest on account of its recent advent into the bituminous field. The following is some data on this process washing nut and pea coal:

TABLE F

NUT—2½" x 1"
PEA—1" x ⅛"
ASH

	Pct.	Pct.
Feed coal	14.3	9.9
Washed coal	10.6	9.2
Refuse	60.3	68.6
Reject	7.5 (calculated)	1.2

Washability studies Shown on 2½" x ⅛" 12.14% Ash

Washed coal	Refuse	Grav. of washing
86.40% @ 6.5% Ash	13.6% @ 45.1% Ash	1.55
89.30 @ 7.7 Ash	10.7 @ 49.4 Ash	1.60
96.20 @ 10.0 Ash	3.8 @ 66.5 Ash	1.75

"The washing gravity apparently set up is 1.75. At this point Mr. Drakeley steps in with the Delatester and shows on the nut coal:

Float in feed coal at 1.75 sp. gr.	95%
Float in washed coal at 1.75 sp. gr.	96%
Float in refuse at 1.75 sp. gr.	31%
Qualitative efficiency	20.0%
Quantitative efficiency	97.4
Bank loss	2.6

TABLE C

Dry table refuse from going plant—2½" x 0"

General Data:

Total weight of samples: 637 ounces

Sizing Tests:—

Denomination	Weight, Ounces	Pct. Weight	Pct. Ash	Pct. Sul.	Weight Pct. of Feed
2½"—1 "	130	20.4	49.6	..	20.4
1 "— ½"	137	21.5	48.5	..	21.5
½"— ¼"	129	20.2	36.7	..	20.2
¼"— ⅛"	129	20.2	33.8	..	20.2
⅛"—0 "	112	17.6	18.8		
Total	637	99.9			
Average			38.06		

—⅛"	Weight, Ounces	Pct. Weight	Pct. Ash	Pct. Sul.	Weight Pct. of Feed
Over 14 mesh *	402	50.0	22.8	..	8.8
Thru 14 mesh * over 28 mesh	157	19.5	15.0	..	3.4
Thru 28 mesh over 48 mesh	94	11.7	13.7	..	2.1
Thru 48 mesh over 100 mesh	72	9.0	14.0	..	1.6
Thru 100 mesh over 200 mesh	50	6.2	16.0	..	1.1
Thru 200 mesh	29	3.6	16.6	..	0.6
Total & average	804	100.0	18.8		99.9

* 14 Mesh is equivalent to 1/16" round hole screen.

Size: 2½—1"
Curve No. 203-B

Specific gravity		Weight, Pet.	Ash, Pet.
	Float 1.32	2.85	4.7
Sink 1.32	Float 1.46	20.60	11.8
Sink 1.46	Float 1.60	5.67	25.7
Sink 1.60	Float 2.00	4.47	46.7
Sink 2.00		66.40	65.5
Total		99.99	
Average			49.6

Size: 1—½"
Curve No. 203-C

Specific gravity		Weight, Pet.	Ash, Pet.
	Float 1.32	6.85	4.8
Sink 1.32	Float 1.46	16.52	9.9
Sink 1.46	Float 2.00	9.26	37.0
Sink 2.00		67.40	64.0
Total		100.03	
Average			48.5

Size: ½—¼"
Curve No. 203-D

Specific gravity		Weight, Pet.	Ash, Pet.
	Float 1.32	23.3	5.6
Sink 1.32	Float 1.46	19.5	9.6
Sink 1.46	Float 2.00	9.9	37.6
Sink 2.00		47.2	63.0
Total		99.9	
Average			36.7

Size: ¼—⅛"
Curve No. 203-E

Specific gravity		Weight, Pet.	Ash, Pet.
	Float 1.32	37.85	4.2
Sink 1.32	Float 1.46	13.93	11.1
Sink 1.46	Float 2.00	7.63	36.0
Sink 2.00		40.60	68.6
Total		100.01	
Average			33.8

Size: 2½—⅛" (Comp.)
Curve No. 203-F

Specific gravity		Weight, Pet.	Ash, Pet.
	Float 1.32	17.50	4.7
Sink 1.32	Float 1.46	17.60	10.6
Sink 1.46	Float 2.00	9.50	36.4
Sink 2.00		55.60	65.0
Total		100.20	
Average			42.3

TABLE B—CHEMICAL ANALYSIS METHOD
Washing 5/16" x 0"—Bituminous coal

Retained on	Wt. %	Cum. Wt. %	Ash %
5/16 in. or 2½ mesh	.7	.7	33.7
⅛ in. or 6 mesh	23.3	24.0	23
1/16 in. or 14 mesh	39.2	63.2	15.5
48 mesh	25.4	88.6	17.0
100 mesh	6.0	94.6	18.8
200 mesh	2.6	97.2	20.0
Through 200 mesh	2.8	100.0	18.1

(Average 15 percent ash feed):

1927	% Figured recovery	Washed Coal Ash Pct. Actual	Theo.	Refuse Ash Percent Actual	Theo.	% Actual recovery
Jan. 16 to 31	82.1	10.20	9.0	48.10	51.1	....
Feb. 1 to 15	82.6	10.10	9.1	49.70	51.9	....
Feb. 16 to 28	83.2	10.15	9.4	51.20	53.0	....
Mar. 1 to 31	83.2	10.17	9.4	50.83	53.0	81.8
July 1 to 31	82.0	10.30	9.8	49.20	51.0	82.6

1928	Pct. Ash in Feed	Tons Fed Per Hr. Run	Tons W. C. Produced Per Hr. Run	Figured Recovery	Pct. Ash in W. Coal	Pct. Ash in Refuse	Hrs. Run
Mar. 9	15.5	129.4	114.9	85.2	9.8	48.4	4–40
Mar. 10	16.1	126.8	110.7	84.9	9.8	51.5	7–35
Mar. 12	15.8	130.5	115.3	85.9	9.6	53.8	5–30
Mar. 13	15.4	127.7	112.4	86.4	9.5	53.1	8–10
Mar. 15	15.3	127.6	110.3	86.5	9.8	50.5	9–10
Mar. 17	15.4	132.7	115.7	87.2	10.1	51.7	4–00
Mar. 20	15.1	132.2	115.6	86.7	9.7	50.2	7–50
Mar. 21	15.5	130.0	117.0	86.6	9.9	51.8	7–30
Mar. 22	15.9	134.0	117.3	85.7	9.7	53.1	5–45
	9)140.0			775.1	87.9	464.1	
	15.6			86.1	9.8	51.6	
				Theoretical approx.	9.0	55.0	

TABLE D—WET TABLE REFUSE FROM GOING PLANT—⅝" x 0"

General Data: Sizing Tests:

Denomination	Weight, Ounces	Pct. Weight	Pct. Ash	Pct. Sul.	Weight Pct. of Feed
⅝"—5/16"	68	19.4	40.5	3.71	19.4
5/16"—0	282	80.6	26.9	4.86	
Total and ave.	350	100.0	29.6	4.65	
5/16"—	Grams				
Over 14 mesh *	904	47 6	34.9	5.65	38.4
Thru 14 mesh * over 28 mesh	605	31.6	21.3	4.24	25.7
Thru 28 mesh over 48 mesh					
Thru 48 mesh over 100 mesh	390	20.5	17.3	4.03	16.5
Thru 100 mesh over 200 mesh					
Thru 200 mesh					
Total and ave.	1899	100.0	26.9	4.86	100.0

* 14 Mesh is equivalent to 1/16" round hole screen.

ASH TEST

Size: ⅝"—5/16"
Curve No. 212-B

Specific gravity		Weight, Pct.	Ash, Pct.
	Float 1.300	7.26	3.5
Sink 1.300	Float 1.380	15.60	11.0
Sink 1.380	Float 1.575	17.90	24.5
Sink 1.575	Float 1.800	14.90	39.1
Sink 1.800	Float 2.000	15.78	53.0
Sink 2.000		28.50	70.0
Total		99.94	
Average			40.5

Size: 5/16"—14 mesh
Curve No. 212-C

Specific gravity		Weight, Pct.	Ash, Pct.
	Float 1.300	11.3	3.0
Sink 1.300	Float 1.380	14.3	9.2
Sink 1.380	Float 1.575	17.6	23.5
Sink 1.575	Float 1.800	18.7	37.9
Sink 1.800	Float 2.000	14.7	49.0
Sink 2.000		23.3	63.7
Total		99.9	
Average			34.9

Size: 14—48 mesh
Curve No. 212-D

Specific gravity		Weight, Pct.	Ash, Pct.
	Float 1.300	36.4	2.2
Sink 1.300	Float 1.380	20.8	8.1
Sink 1.380	Float 1.575	13.4	20.7
Sink 1.575	Float 1.800	6.7	36.5
Sink 1.800	Float 2.000	5.6	49.2
Sink 2.000		17.1—	63.5
Total		100.0	
Average			21.3

Size: ⅝"—48 mesh (Composite)
Curve No. 212-E

Specific gravity		Weight, Pct.	Ash, Pct.
	Float 1.300	18.1	2.55
Sink 1.300	Float 1.380	16.7	9.16
Sink 1.380	Float 1.575—	16.4	23.10
Sink 1.575	Float 1.800	14.1	38 00
Sink 1.800	Float 2.000	12.2	50.30
Sink 2.000		22.6	65.50
Total		100.1	
Average			32.10

"This result is in line with what Professor Locke, of Boston Tech., has to say about this type of coal washer:

"'The investigations of Robert H. Richards and others on ores have demonstrated the laws of sizing, of classification by free and hindered settling, of jigging with pulsion and suction, and of washing on tables. An elementary knowledge of these laws is sufficient to show the advantage of jigging a sized product as compared to an unsized product, or of using classified products as feed, and the futility of expecting a coal washer of the classifier type, such as the Robinson washer or the Menzies hydroseparator, to be able to remove anything but the coarser particles of slate, leaving the fine still mixed with the coal. There still remains the unexplored field of stratification, as in the Rheolaveur, the laws of which have not been studied in an experimental way. When these laws become known, it is not at all unlikely that they will be found to have application in the treatment of ores as well as coal.'

"It seems to me that the natural and sensible thing to do to handle this kind of coal is to install flexible and efficient washing apparatus, one that will make 6½ percent ash washed coal when it is needed with the minimum bank loss. The washability study table shows what is best along this line. When chemical quality becomes a factor in the sale of domestic sizes, the roughing job, which is largely used to improve 'visual inspection,' will be supplanted by more efficient types of cleaning.

TABLE G

WASHER PLANT "A" (Efficient)

Input ..... 1,000 tons in 8 hours
Output ..... 900 tons in 8 hours
Refuse ..... 100 tons in 8 hours
Recovery, 90 percent.
Initial cost, $75,000.
Cost of coal..... $1.80 per ton
Cost of washing..... .10 per ton
Conversion cost..... .20 per ton
($1.80÷.90=$2.00 and $2.00—$1.80=$0.20)
Total cost of washing, 30 cents per ton.
Performance of washer:
Feed coal contains..... 11.5% Ash
Washed coal contains..... 6.0% Ash
Refuse coal contains..... 62.0% Ash
Reject coal contains..... 10.0% Ash
10 percent sink in feed coal.
2 percent sink in washed coal.
5 percent float in refuse (all sizes) at washing gravity.
Qualitative efficiency 82 percent (in terms of feed coal).
Quantitative efficiency 99½ percent (in terms of feed coal).
Bank loss one-half percent (in terms of feed coal).
$1.80 x ½%=$0.009 per ton and
1000 x $0.009=$9 per day or
$9.00 x 300=$2,700 per year=value of bank loss

TABLE H

WASHER PLANT "B" (Inefficient)

Input ..... 100 tons in 8 hours
Output ..... 895 tons in 8 hours
Refuse ..... 105 tons in 8 hours
Recovery, 89.5 percent.
Initial cost, $75,000.
Cost of coal..... $1.80 per ton
Cost of washing..... .10 per ton
Conversion cost..... .21 per ton
($1.80÷.895=$2.01 and $2.01—1.80=21 cents)
Total cost of washing, 31 cents per ton.
Performance of washer:
Feed coal contains..... 11.5% Ash
Washed coal contains..... 7.0% Ash
Refuse coal contains..... 50.0% Ash
10 percent sink in feed coal.
4 percent sink in washed coal.
30 percent float in refuse (all sizes) at washing gravity.
Qualitative efficiency 65.2 percent (in terms of feed coal).
Quantitative efficiency 96.8 percent (in terms of feed coal).
Bank loss, 3.2 percent (in terms of feed coal).
$1.80 x 3.2%=$0.0576 per ton and
1000 x $0.0576=$57.60 per day or
$57.60 x 300=$17,280.00=value of bank loss, annually
$17,280—$2,700=$14,580 net saving by efficient washing plant
$14,580=interest at 5% on $295,160

Convenient form for float—and—sink data

CHEMICAL TEST DATA

on

_____WASHERY

Qualitative Efficiency = _____% ASH Quantitative Efficiency = _____%

Date	FEED COAL				WASHED COAL				REFUSE				TONNAGE		% REFUSE			
	Ash in Float	Ash in Sink	Comp. Ash	% Sink	Ash in Float	Ash in Sink	Comp. Ash	% Sink	Ash in Float	Ash in Sink	Comp. Ash	% Sink	Coal	Refuse	By Wts.	By Calcn.	Hours	t. Gr.*
Ave.																		
Cum. Ave.																		

* Washing gravity and testing gravity must be the same.

Remarks: _____

"In the Tables G and H are shown two set-ups which are self-explanatory. Exact niceties are not used in figuring and there are some hypotheses. The coal is the Pocahontas No. 4 seam and the washability conclusions are based on a careful washability study. I have been rather mild in the inefficient job. Actually I have seen tests showing much worse on going plants in the district—5 to 6 percent sink in washed coal and 40 to 50 float in refuse at the washing gravity.

"The main point is that the inefficient job is insidious. The cost of washing on the face is no more than the efficient job, yet there is an annual waste of coal amounting to $17,280. The 'bug' is that the 'float' coal in the refuse ought to replace high ash 'sink' in the washed coal, thus making for quality as well as quantity. It is only a mathematical conclusion—30 percent float in a 10 percent refuse is 3 percent loss of feed. This float may run 12 to 15 percent ash at the washing gravity. This 3 percent feed with 12 percent ash, in an efficient job, simply replaces 3 percent of high ash sink with, say, 50 percent ash in washed coal. The net result is that the efficient job shows about 1 percent lower ash in the washed coal. In metallurgical practice this is worth 30 cents per ton, according to Sweetser, or 20 cents per ton of coke. In intercompany business the 1 percent ash 'edge' would take care of the total cost of washing.

"A pertinent question at this point is, What is going to happen to the operator who has the inefficient 7 percent ash washer when he is asked to produce a 6 percent ash quality product? A little experience is the best teacher. When the 'coal end' is good, the 'rock end' goes to pot, and when the 'rock end' is somewhere near the theoretical ash, the sales department can't sell the coal. That's the usual answer in the inefficient job. It isn't altogether a question of how dry or how wet the cleaned coal is, of how dusty the plant is, or what the sludge or moisture problem is, although all these are factors; after all, it is quality that must eventually sell the coal. Six percent ash with 5 percent moisture more than offsets 8 percent ash with 3 percent moisture if all factors are considered.

"In conclusion, I feel that my efforts toward bringing about higher efficiencies in coal washing must eventually bear fruit. The inefficient apparatus must be 'backed off the boards' entirely. The coal operator will profit thereby, for whatever type of cleaning equipment he may install in the future, he can reasonably be certain that it will be more efficient than anything that has gone before. There is no other answer if there is to be progress in the art."

DRY CLEANING AT BERWIND-WHITE

(*Continued from page* 540)

those who intend to use coal for the making of coke, especially in the by product ovens. It is a well-known fact that moisture above certain limits has an injurious effect on by-product coke oven linings and also produces an undue amount of moisture, which has to be recondensed and handled in the by-product systems.

"The steam coal trade, up until recently, has not made any great demands on the coal producers as to the moisture content. With the continuous increase, however, of the number of pulverized fuel installations, there is coming to be more and more of a demand for dry coal. That is due to a mechanical reason, perhaps, bound up in the fact that they usually have to have fairly dry coal before they can grind it.

"There is also, however, the question of plain dilution of the product. If you are buying coal and are paying for 1 percent of moisture, then that 1 percent is actually as much of a dilutant of your product as 1 percent of ash, with the possible exception that 1 percent of ash represents something more than 1 percent of refuse. For example, a piece of slate is not 100 percent ash. It may be 70 percent, and, therefore, that piece of pure slate represents perhaps 1½ percent of inert matter.

"On the other hand, water takes in the neighborhood of 1,400 b.t.u. to raise it to the temperature of flue gas from ordinary temperatures. That is more heat than is required to raise a piece of slate from ordinary temperatures to the temperature of the fuel bed. This difference puts moisture in a class with ash as an inert material.

"It is our feeling, then, that the Berwind-White Company, in taking this attitude regarding moisture, are just a few jumps ahead of the field."

(In answer to an inquiry MR. NEWBAKER stated:)

"The percentage of large sizes is so small that we feel that the moisture added by this one unit, will be such a small amount that it will compensate for some disadvantages that you have with air tables on the larger sizes of coal.

"We have in our first plant a table working on coal ranging from 3½ to 2 in. I think that is probably the biggest air table in operation today. The result are fairly satisfactory but not entirely uniform. They are not as uniform, we believe, as can be obtained by a wet process. As possibly 10 percent of this coal will go through a wet process, and the surface moisture adhering after a drying process over a screen will be reduced possibly to 1 percent, you can see the added moisture to the entire run-of-mine product will be possibly in the neighborhood of .1 of 1 percent."

CLEANING COAL *at* VON STORCH COLLIERY *of* SOUTH PENN COLLIERIES COMPANY*

By THOMAS F. STEELE †

Description Of New Plant Built To Replace Antiquated Breaker—Loading Booms To Prevent Degradation—Steel Structure — Rotary Dumps—Four Chance Separator Cones—Advantages Of Present Method, Percentage Of Coal Sizes, Recovery Of Marketable Product, Economy Of Operating Costs

THE new Von Storch Breaker of the South Penn Collieries Company, employing the Chance Sand Flotation method of preparation, is located at Scranton, Pa., and was completed for operation in January, 1927.

This new plant or breaker was erected for the following purposes:

First. To replace two antiquated wooden breakers, the life of which had been exhausted and requiring large annual maintenance cost; these structures being over a mile apart and known as the Legitt's Creek and Von Storch Breakers.

Second. To provide a preparation plant that would bring the market product of the company up to the highest possible standard.

Thomas F. Steele

Third. To secure the maximum economies in operation by reduction in maintenance and operating costs.

Fourth. To reduce the loss of coal to the refuse bank to the minimum.

This new plant, which is of steel construction, was erected on the site of the old Von Storch Breaker, having been built in and around the old breaker in a period of approximately four months, during which time the old Von Storch Breaker continued in operation, thereby eliminating the necessity of shutting down the mine during the reconstruction. The only time lost was approximately two weeks in changing over from the old to the new method of operating.

The first step in the preparation of coal through this plant is, of course, the dumping of the run-of-mine, which is hoisted up a double-track rock slope a maximum distance of 1,800 ft. at a rope speed of 1,200 ft. per minute by means of a double-drum electric hoist of 450 hp. The pitch of this slope, on which there are three landings, is 12 degrees or 22 percent, and the two tracks converge into a single track at the point at which the mine car trip, consisting of six cars, enters and leaves the rotary dump, both ropes operating through the dump.

This six-car rotary dump is the largest installation of its kind in the anthracite field and is operated by one man. The coal is discharged from this dump onto an apron conveyor running the full length of the rotary dump. This conveyor delivers the material to the main, or bull shakers, where that portion of it which passes over a 4½ in. round mesh goes to a movable picking table for the purpose of removing the large rock before sending the material to a set of main crushing rolls. This set of rolls is 51 in. in diameter, with a face of 50½ in., and operates at a speed of 22 r. p. m.

The material passing through the 4½-in. round mesh and over a 3 7/16-in. round mesh is sent to what is known as the "pony" or No. 2 rolls. The No. 2 rolls are 36-in. in diameter, with a face of 57-in. and operate at a speed of 28½ r. p. m. The material from these rolls is mixed with the material of the same size which comes from the main rolls. Both the main and No. 2 rolls are of the hollow ground, driven tooth, standard anthracite type.

We now have all material reduced to a commercial size combined at one central point, which is a receiving hopper located directly below the No. 2 rolls. The material thus assembled passes from the hopper to mechanical shaking chutes, where it is divided and delivered to four shakers, which in turn deliver the material to the slate separating equipment.

The use of shakers for delivering the crude material, after having been broken down to the present commercial sizes, is to eliminate culm or silt—or that material passing through a 1/16-in. mesh—before delivering the product to the cone, thus maintaining clean sand and more constant gravity in the cone.

The slate separating equipment consists of four 13½-ft. diameter Chance Separator Cones (very much like the Robinson washer) fitted with top and bottom slide valve slate gates and a refuse chamber located between the two gates. On the top of the cone are two offsets, one allowing for sand and water return, and the other for the overflow from the cone.

The product to the cones is passed over a double-deck shaker, the upper deck carrying egg, stove and chestnut sizes and the lower deck carrying the smaller sizes. Each of these groups of sizes enter the cone at different points, the first mentioned, known as the domestic sizes, approximately 5 ft. from the point of discharge, and the second group, known as the steam sizes, about 10 ft. from the point of discharge, experience having developed that the respective sizes at our operation are thoroughly cleaned after traveling the aforementioned distances.

In the operation of the separator, a mixture of sand and water is introduced into the cone, completely filling it and causing the sand and water to overflow. The sand particles are kept in suspension in the fluid mass by means of mechanical agitation and by the addition of hydraulic pressure discharged into the separator tank through jets connected to the classifier column of the cone. To aid in keeping up agitation and prevent the sand from banking along the sides of the cone, an agitator is kept slowly revolving in the center of the cone, being driven by a set of bevel gears located directly above the cone. The fluid mass thus provided can be maintained at a density of approximately 1.75. The mixture of coal and refuse is fed into the separator and the clean coal floated out over the overflow while the refuse sinks to the bottom of the cone, due to its higher specific gravity. At required intervals the refuse is released from the cone by means of interlocking slate gates operated by compressed air or steam, the operation of the slate gates being so adjusted as to remove the accumulated refuse from the classifier column into the refuse chamber, and from the refuse chamber into a water sealed refuse conveyor, without disturbing the fluid mass in the separating cone.

It has been the general practice in the anthracite field where Chance separators are in use, to have a cone attendant at the coal end and a slate attendant at the slate gates, or two operators for each cone. At Von Storch we have devised a system of control levers, connected by means of cables, so that the one attendant takes care of two cones, thereby eliminating the services of three men, or a total economy of six men for the battery of four cones in this plant. This arrangement not only effects a saving of six men in our force, but the operator who observes the character of the material entering the cone is best situated to trap out the rock or slate at the proper time.

The sand used in obtaining the required gravity in the separator cones is mixed with water in two large, cone-shaped mixing tanks located at a lower level, one for each pair of separator cones, from which the sand is delivered to each cone by individual sand return pumps of 2,000 gallons capacity each, operated by 50 hp. variable speed electric motors.

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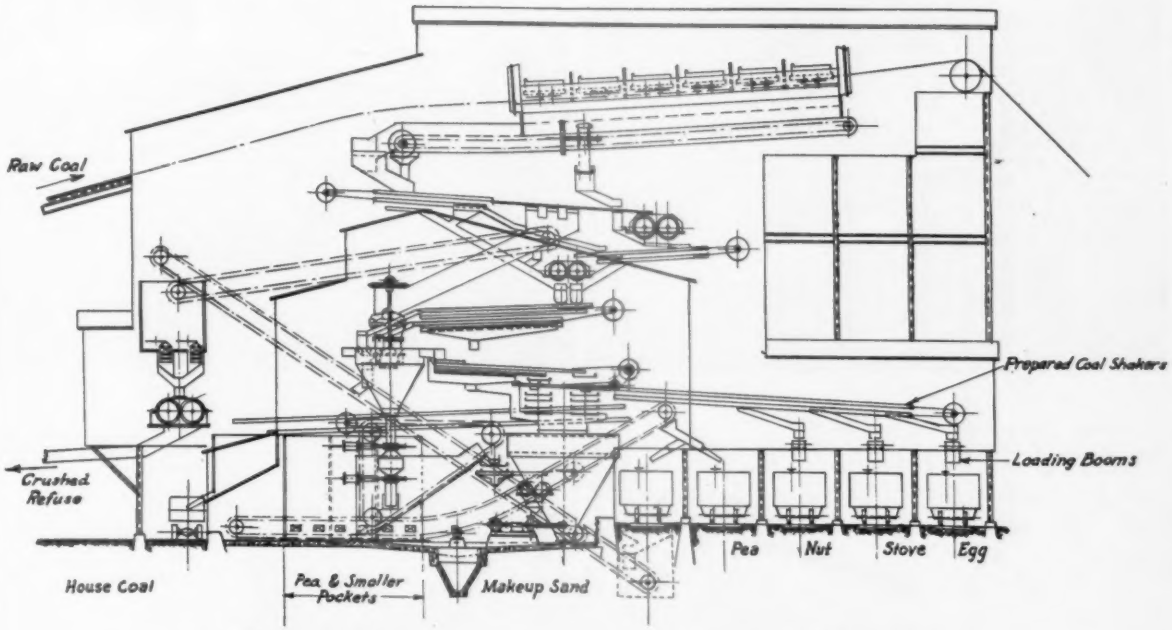
* Presented to 5th Annual Convention of Practical Operating Men, Cincinnati, Ohio, May 9, 1928.

† General Superintendent, South Penn Collieries Company.



Side elevation, Von Storch Breaker of the South Penn Collieries Co.—Four type F sand flotation cones cleaning all sizes washed

There are also two 1,400-gallon auxiliary sand sumps located below the level of the concrete floor of the breaker, to which all escaping sand is drained and later reclaimed for use in the cones. This drainage arrangement at Von Storch has been one of the major factors in the low sand consumption per ton of coal produced. Careful data kept on the consumption of sand during the past six months of operation show a consumption of 3.7 pounds per ton of production, at a cost of $0.0063 per ton of coal. This compares with an average sand consumption of 6 to 15 pounds per ton of production at other plants and is the lowest in the anthracite field.

Other factors in this low sand consumption are ample desanding shaker area and a plentiful supply of wash water on the desanding and sizing shakers, making possible the reclamation of the maximum amount of sand from refuse.

To permit recovery of sand which escapes with the slate, all refuse from the cones is discharged on a set of shakers where the sand is removed and returned to the system through the auxiliary sand sumps previously described.

The main supply of sand is stored in bins on the bottom floor of the breaker. As additional sand is required in the system, it is flushed from the storage bins to the auxiliary sumps located on the same floor, from which point it is pumped by means of two 500-gallon pumps direct to the cones.

The coal is discharged from the cones on to eight sets of shakers, two for each cone, where the prepared sizes are separated from the steam sizes and at the same time any particles of sand that may have come out with the coal are removed. The domestic sizes then pass over the boom shakers for final sizing, thence to the boom loaders and direct into railroad cars. The steam sizes pass over separate shakers for final sizing, thence into pockets from which they are loaded into railroad cars by means of conveyors.

Our method of loading the coal into railroad cars by means of boom loaders for the domestic sizes and conveyors for the steam sizes is comparatively new to the anthracite region. The loading facilities throughout the entire region generally consist of large storage pockets for each size, from which the coal is drawn or dropped into railroad cars.

The old pocket method of loading not only necessitates a considerable expenditure in the construction and maintenance of the breaker, but causes excessive degradation, first in dropping the coal into the pockets, and secondly, in dropping it from the pockets into the railroad cars. The degradation caused by dropping the coal into the pockets is to some extent removed by means of lip screens, but the degradation caused by dropping the coal into the railroad cars can not, of course, be eliminated.

With boom loader and conveyors, the so-called pocket degradation is eliminated and the degradation in railroad cars under our present method of loading is one-half of 1 percent, compared to approximately 2 to 4 percent degradation under the old method of loading from pockets.

This new method of loading in the anthracite field is quite common to the bituminous field, and is a decided factor under the present-day market requirements for anthracite. To obtain some idea of what the degradation or breakage in railroad cars means to a dealer, we will assume that domestic coal is costing him $12 per ton delivered at his yard. On 100 tons, under the old method of loading, the dealer would receive 2 to 4 tons of fines which must be sold by him at a loss, while under our method of loading, with the same kind of material, the maximum fines would not exceed one-half a ton, or a saving to the dealer of approximately 10 to 20 cents per ton on all coal purchased.

The first installation of boom loaders in the anthracite field was made by the present management of the South Penn Collieries Company several years ago for a neighboring anthracite company, this also having been applied to a Chance plant, which was the first of its kind to be successfully operated.

Because of the limited time allotted for the discussion, I have only covered in a general way the sand flotation plant as it applies to our Von Storch Colliery, complete detail and description of which can be secured by communicating with the Chance Coal Cleaner Company, Scranton, Pa.

Briefly, the advantages of the process and the results we have obtained which will no doubt be of more real value to you than the general description of the plant, are as follows:

(a) A better prepared and more uniform market product.

(b) Maximum recovery of marketable material from the run-of-mine product.

(c) Economies in operating cost.

(d) Economies in initial cost or cost of construction.

(e) Better realization and full time operation.

The Von Storch Breaker

(a) Better Prepared and More Uniform Market Product

There is no doubt that with the Chance flotation method a more uniform and cleaner market product can be secured than is possible with the ordinary jigging methods used in the majority of anthracite breakers. This is borne out in our case by the fact that with every car of prepared sizes carefully inspected at the breaker for slate, the average slate content in our market product for the past six months compared with the accepted standards of the anthracite industry has been as follows:

Size coal	Pct. Slate Von Storch	Pct. Slate Accepted standards
Egg	0.20	2.00
Stove	0.20	4.00
Nut	0.56	5.00
Pea	2.50	6.00

Samples also taken of each car of steam coal and an ash analysis made at the plant, indicate that the improvement in steam coal preparation is equally as good, if not better, than in the domestic sizes. For example, our buckwheat coal has averaged 10 percent in ash for the same six months period as compared with the accepted standard of 18 percent ash.

This performance compared with the average performance of the old breakers in prepared sizes is as follows:

Size coal	Pct. Slate New breaker	Pct. Slate Old breaker
Egg	0.20	2.00
Stove	0.20	4.00
Nut	0.56	5.00

(b) Maximum Recovery of Marketable Material from Run-of-Mine Product

This, of course, is determined by the percentage of coal found in the slate, or breaker refuse banks, and the total yield of coal per hundred cubic feet of production.

The loss to the refuse bank, for a 10 months period with the present plant as compared with the performance of the old breakers is as follows:

	Present p'lant	O'd br'akers
Coal	0.60%	4.0 %
Bone	1.22%	7 55%
Total	1.82%	11.55%

We have found that it pays to follow up closely the percentage of coal in the refuse, which is done by having installed in the breaker near the slate discharge a zinc chloride tank for testing the refuse at least every hour throughout the day.

As to the merchantable yield of coal per hundred cubic feet, the following is a comparison of the results obtained from the new breaker with those obtained from the old plant:

Old breakers .....2.559 tons per 100 cu. feet
New breaker .....2.605 tons per 100 cu. feet

(c) Economies in Operating Cost

A comparison of the force required to operate the Chance breaker with that required for the two old breakers is as follows:

Old breakers .....71 men and boys
New breaker .....24 men and boys

This indicates a saving of 47 men, or the equivalent of $220 per day in labor, and at the same time we have increased our production approximately 20 percent.

As I stated before, we use 3 7/10 pounds of sand at .0063 cents per ton. The sand, pump, material and labor on maintenance run us about $400 a month, which on our tonnage gives us a cost of .0066. The two men who operate the sand return pumps will cost .004 per ton, or a total cost of operating the sand pump and maintaining same of .0106.

The cones and water lines during the past year, or material and labor charged on maintenance, has been only .0006. The two men who operate the cones cost .004, or a total of .0046.

On sand sumps and sand lines maintenance there is also a cost of .0004. We have had to change the rock gates once in the last year and three months, which cost .0006. The rock conveyor lines carrying the slate from the slate end have been replaced once, which cost .005, and the water lines to the rock gates cost .0004. The total cost of operating and maintenance on the cones themselves, plus their pumps and sand mixing arrangement, has been .0279 per ton of production shipped to market.

(d) Economies in Initial Cost or Cost of Construction

The capacity of the present plant, as has been determined by actual performance is 1,250 tons per cone per day, or a total of 5,000 tons per day; and to build and equip a breaker with the type of jigs ordinarily used in the anthracite field would entail a capital outlay of at least 40 to 50 percent more than the cost of this plant.

(e) Better Realization and Full Time Operation

With the market conditions that have prevailed for the past year and a half for anthracite coal, we have been able to obtain better than the line company circular at all times, while we are thoroughly satisfied this would not have been the case had we not been equipped to send to market a high grade product, uniformly prepared. Further, this is borne out by the fact that the smaller or independent companies, who have no storage facilities for stocking their coal, have either had to curtail their operations or sell their coal at prices considerably less than the line company circular, depending upon the season of the year, while our company has been able to operate continuously with the exception of local strikes.

The aforementioned results would indicate that anyone contemplating the construction of a new plant, or the rebuilding or remodeling of an old preparation plant, (*Continued on page* 566)

COAL CLEANING *as a* FACTOR *in* MECHANICAL MINING *and* PRESENT DAY MARKETING*

By ELI T. CONNER †

Early Coal Preparation Practices With Wet Jigs And Dry Cleaning Devices—Modern Methods Have Much Greater Efficiency And Permit Higher Coal Recovery Underground—Mechanical Loading Increases Necessity Of Mechanical Cleaning—Mining And Preparation Methods Should Be Considered Together

PROGRESS in the art of mining and preparing coal in recent years more definitely than ever links together these two activities. Many years contact with mining and preparing anthracite and bituminous coal suggests a brief historical review of both features of this subject.

As one of the younger mining men, it might be of interest to describe briefly to this gathering of "old-timers" my observation of the progress of the art of preparing and cleaning coal during the past 46 years.

My first activity in coal mining was as a general handy-man under the direction of an able superintendent, the late Mr. Walter Leisenring, at Sandy Run, Luzerne County, Pa., and among other things assigned to me was the duty of learning the methods and principles of separation of coal, bone and slate in what was at that time a modern up-to-date coal breaker. This breaker had been designed by the late Mr. Thomas M. Rightor and was fully equipped with the best-known wet separation of that day. Much of the run-of-mine product was that from steep pitching chambers in the Buck Mountain bed, so that nearly all of the slate and other impurities contained in the coal bed reached the breaker. Preliminary treatment was given on a platform, where the large pieces of rock were removed manually, the grate or broken coal being hand picked. The egg and all of the stove and chestnut, together with part of the pea coal, passed through jigs, some of which were Stroh, made at Mauch Chunk, Pa.; this was one of the early types in use for some years prior to 1882, also the Bradley Jig, and others following the same principle. All of these machines, except the Clark, were known as the pan type, i. e., a circular or rectangular receptacle with a perforated bottom suspended to a vertical shaft in a water-filled tank and actuated by a vertical steam engine. This type jig is too well known to need further description. This device did very good work for that period, but its success was dependent upon the human element, proper judgment of the operator. The operator was usually a boy of 12 to 14 years, some of whom became quite expert in judging the time for opening the slate valve and regulating the speed and feed input.

It was my great privilege while serving as general handy-man, and later as engineer and assistant superintendent, at Sandy Run, Pond Creek and Harleigh to make the acquaintance of the late Eckley B. Coxe. As you doubtless all know, Mr. Coxe was one of the most progressive and highly educated mining engineers and operators of that period. He had a well-equipped testing laboratory and technical library at Drifton, and did not hesitate to spend money in experimental work in connection with the mining and preparation of anthracite coal. Mr. Coxe was the inventor of the Coxe Stoker, out of which has grown the modern practice of automatic stoking devices for the burning of small sizes of anthracite. About the year 1885 Mr. Coxe, who had finished his technical education at Freiberg, Germany, observed in Germany separating machines or jigs differing in principle from the pan jigs, which I have mentioned, and which at that time were in quite general use in the Lehigh and Schuylkill Regions; this difference consistin~ in the agitating element of the jig, which was a plunger, moving vertically in a separate compartment of the jig tank, so that the water passed upwards through the perforations in the bottom of forward compartment of the jig, lifting the coal and impurities, and causing separation by the slate settling to the bottom and the coal overflowing at the front of the jig. The Coxe jig was a distinct advance upon the pan type.

In 1888 I became superintendent of a small anthracite mine owned by the Mount Jessup Coal Co. (Ltd.), located at Jessup, Lackawanna County, Pa. At that time the generally accepted practice in the northern anthracite region was to prepare coal dry. The managers and producers were quite opposed to putting water in their breakers and had many arguments to advance in support of the practice which had prevailed from the beginning of the industry in this respect. There were many devices for the separation of impurities, which were dependent upon friction plus the difference in specific gravity between coal and impurities, but all of these devices, such as the Zeigler, Emery and others, were incapable of adjustment to provide for the varying character of the run-of-mine product. Fairly good results were attained with the dry separators, so long as the mine run of product was won from the better and cleaner beds of coal, such as the Baltimore, Pittston or Grassy Island, all being different names for the same bed, but, as it becomes necessary, by reason of the exhaustion of the big bed (which I should have remarked corresponds to the Mammoth Bed of the Lehigh and Schuylkill Region), to get some of the mine run product from thinner and leaner beds of coal, the production of a marketable commodity could only be accomplished by excessive loss in the "tailings."

Soon after taking charge of the Mount Jessup Mine, where at that time there was but one workable bed of coal, i. e., the Clark, which carried from 25 to 35 percent of impurities in four to six benches, I became convinced that dry preparation was not, and could not, be made to work out successfully. Therefore I installed, on one side of the breaker, 4 Stroh pan-type jigs, and on the other side, 4 Coxe plunger-type jigs. With this change in method from dry to wet preparation, I was able to convert a losing enterprise into a profitable one. This change was made about the year 1889, and I believe it was the first introduction of wet preparation of the major product at any coal breaker in the northern anthracite region. The success of this method of separation fully convinced me that wet preparation ought to, and would, supersede the prevailing dry method. To a considerable extent this did result, but not until 1915, when I became connected with one of the large producing companies in a consulting capacity, was wet preparation fully adopted by that corporation. When I say wet preparation in this instance, I mean wetting of material after the main rolls, and sizing it on shaking screens, thence through jigs, all of which process is wet. During the past 10 years most of the producers in the northern anthracite field have adopted wet preparation, and there have been several types of jigs introduced with results fully justifying the change from the old dry methods of separation.

In the preparation of anthracite coal, after it has been roll treated to market sizes, the fundamental problem is the separation, or skimming off, on the first pass, of the largest possible proportion of the feed, or input, in a marketable and merchantable condition, with minimum degradation. This principal function is usually designated as "primary treatment."

The secondary function of the separating apparatus should be classed as reclamation or salvage of merchantable coal contained in the reject of any separating apparatus. These two grades of material can best be treated separately, as quite different adjustment is necessary for best results in any mechanical separator. The question of adjustment of jigs to accomplish the foregoing has always been found difficult; largely because of the human element, i. e., that success is dependent upon fine adjustment by a man or boy to produce a marketable product without excessive loss in good coal or bone in tailings. While I have much data upon the performance of various types of jigs, it is not necessary to go into it now, except to say that the principal problem for solution, or, I might say, for correction of jig practice, was, from the beginning of my connection with the mining industry,

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† Consulting Engineer, Scranton, Pa.

the proper conduct of what I have designated as the "secondary operation," or what might be termed as the "Twilight Zone." This "Twilight Zone" varies from 10 to 30 per cent of the gross input and varies within itself in the matter of containing "pure rock," "bad bone," "good bone" and "pure coal." These four divisions of the "Twilight Zone" product vary widely in specific gravity.

It remained for an engineer who was not a mine owner or directly connected with the production of anthracite coal to discover a method which is capable of adjustment, and which does not depend upon the judgment of the operator, i. e., almost eliminating the human element. This device is known as the Chance Coal Cleaner, invented by Dr. H. M. Chance and his son, Mr. T. M. Chance, of Philadelphia. The technical features of this subject have been well covered by the inventors and by Messrs. M. A. Walker, C. Dorrance, and others, and today by Mr. Tom F. Steele. The papers by these gentlemen have doubtless come to the attention of most of the engineers and operators in active contact with coal production, so I need not enlarge thereon. In my study of preparation of anthracite and bituminous coal, I have found nothing as positive as the Chance Separator.

In the matter which I have designated as "primary treatment," I believe it possible by this process to skim off in a merchantable condition a larger percentage of the input of any grade of coal with which I have dealt than by the use of any other device I know of.

I have dealt at considerable length with the history of coal separating apparatus coming under my observation, all of which is, in my opinion, of importance to the engineer and operator. However, there is another feature of the subject of coal production which to my mind is important and contains large possibilities for the consideration of the operator and the land owner, and that is, that with the Sand Flotation Process properly adjusted I believe it possible to recover and suitably prepare beds of coal and benches of other beds, which under other methods of separation could not be commercially won and made into a marketable product. I mean by this, benches of bone, which, under the prevailing practice, are "gobbed" in the mines, could be sent with the better benches of the bed to a breaker or preparation plant and a considerable percentage recovered for market without excessive adulteration of the product. Under the system generally prevailing, the operator requires the miner and his laborer to load a car of "clean coal," and if the miner's car contains what in the judgment of a docking boss, is an excessive amount of slate or bone, the miner is penalized. As to the matter of slate and rock, this long-established practice is absolutely correct, but as to the benches of bone, whether what is known as "bad bone" or "good bone," it seems to me inadvisable to make an inspector of the property of the operator, or the land owner, out of the average miner and his helper, especially the helper, because in order to avoid penalty the miner and his laborer will give themselves the benefit of the doubt and throw into the "gob" what does not appear, with the light of a miner's lamp, to be pure coal. This practice, I know, results in the discarding and probable permanent loss of a considerable percentage of some coal beds which might with proper handling be won and made into a marketable product. It is my belief that with the Chance separator, as I have observed it, a considerable part of the loss of the benches of merchantable bone, without undue adulteration of the market product, is attainable.

Progress in the art of mining in this country during the past 15 or 20 years has been great. Intelligent, progressive engineers and operators are fully alive to the advantages which may be attained by the adoption of suitable mechanical devices for the many and varied activities necessary to the recovery of coal beds of varying thickness, differences in physical characteristics, and differences in the character of the over and underlying strata. More especially have progressive owners and engineers been impressed with the necessity of conserving the thinner and leaner beds of coal, rather than ruthlessly mining only the best, and destroying benches or beds which at the particular time may not be capable of recovery at a profit.

As consulting engineer to several anthracite and bituminous corporations during the past 15 years, the necessity for devising methods of mining the thin and leaner beds at the proper time, to avoid their destruction by pillar extraction in beds beneath, where thin intervals prevailed, it became necessary that I recommend constructive plans for such recovery. For many years prior to 1915 it was the general practice in anthracite, and to a less extent in bituminous mining, to either brush top rock or lift bottom rock, not only in the gangways but in the chambers, where the coal beds were less than four feet in thickness. This meant excessive cost in actual mining work, plus the cost of disposing of surplus rock, which could not be stowed underground. A plan was proposed whereby either roof or bottom would be taken in the gangway only, and all other openings, i. e., the airways and the chambers, or the long-wall faces, as might be adapted to conditions, would be in the coal bed only. Various methods of transporting the coal in chambers or across the long-wall face were considered. The method found generally adaptable in anthracite was the open-bottom scoop, actuated by a double-drum winding engine placed at a suitable location on the gangway. This method, first tried by the Lehigh Valley Coal Company and then suggested by the author, was worked out and perfected by Mr. Cadwallader Evans, then assistant superintendent underground of the Hudson Coal Co. He secured a patent covering part of the process. Under this method there is now produced on a commercial basis in the anthracite region a large amount of coal from beds between 18 and 30 inches thick. Other methods of transporting across the face are rapidly coming into favor, such as conveyors, of the type introduced by Mr. C. R. Claghorn at Vintondale, Pa., about 1900, and more recently the "shaking chute," which I believe was perfected and quite generally used in Germany, and is now being introduced in this country.

My references to these mining devices, in conjunction with the subject of my paper, is because of the fact that mechanical devices of all descriptions for loading coal in the mine, and for transporting coal across the face in thin beds, necessarily is almost prohibitive to "clean coal at the face." Consequently, benches of impurities within the coal bed, falling bone, or slate from the roof, etc., almost inevitably flow with the coal into the mine car. Mine cars containing such a mixture make a mine-run product difficult of suitable preparation, either in the breaker or the tipple. Particularly is this true of the smaller sizes of coal, from the size of egg coal downwards. Coal of this grade can readily and economically be made into a marketable, merchantable product by the use of the Sand Flotation Process, so that, in my opinion, mechanical methods of mining and preparation of coal go hand in hand, and if intelligently conducted in combination make it possible to attain commercial success in the exploitation of coal beds that under methods previously prevailing could not be profitably operated.

The adoption of mechanical methods as applied to all of the activities of mining and preparation of coal is doing much more than reducing the cost and improving the market product. The most important benefit, in my opinion, is the great stimulation of the inventive faculty of everyone connected with the industry, and the growing willingness of owners, managers, engineers and workers to discard old and obsolete practices and adopt proven improvements.

This convention, and the accompanying show of mining and preparation apparatus, is a highly important contribution to the industry.

The growth of the American Mining Congress under its progressive leaders is an index of the wide-awake state of "miners"—growth and progress are sure to follow.

COL. W. J. O'TOOLE, in discussing the general subject of mechanical cleaning of coal, following Mr. Conner's paper, said:

"In the old days in mining, if you got within 4 or 5 ft. of the prescribed width of your room, or heading, thickness of your rib, there was nothing said, although there might be some unfavorable results. At the present time we are requiring our operatives to get within at least 6 in. To the mechanical man that would not appear to be very close. However, we find this is advisable from a safety as well as an efficiency standpoint. Since we have adopted these methods we are getting better results.

"With mining machinery we believe that we can get more precise mining than we can by hand mining, providing the machine operatives are looked after, for the reason that machine operatives produce larger amounts of coal per day.

"The great difficulty in the cleaning of coal in the last few years has been the increased cost of labor. We find that it is to our advantage to pay a good wage and get a good man. When you have a high-priced man in any occupation, it is advisable to have him perform only the essentials. Picking out impurities in the coal mine requires a great deal of time, and when you employ a man, and expect him to use half of his time hand-picking the coal before he sends it out, you are wasting money, for the reason that with our latest and most up-to-date methods of transportation we can transport any material, coal or rock, a mile or so for a very small amount per ton. Therefore it pays to bring this refuse outside, even in hand mining, to have it cleaned on the outside by machinery.

"I have been interested in the subject of mechanical cleaning for a number of

years. I have made investigation after investigation of the different methods and types used. I have found most of them satisfactory up to a certain point. In fact, it is hardly possible to get any method that is satisfactory in all respects. The location of the mines and the location of the market are important factors in the method of cleaning. The purpose for which the coal is required is also an important factor.

"I believe that the average freight rate on coal in the United States today is about $2.50 a ton; that is, averaging the long hauls with the short. If it is necessary to transport incombustible material a long distance—for instance, in cases in which the cost of delivery to market is as much as $6 or $7 a ton, it will warrant a larger expenditure for cleaning than short distances. In fact, it has been determined by the combustion engineers that coal will, at the present price, stand a reasonable cost of cleaning even if it is used at the mouth of the mine.

"We have one particular instance under consideration at the present time in which the hand-picked impurities are loaded and shipped to a power plant, pulverized and burned under powdered fuel boilers. That refuse, or that coal, or that fuel, whatever you wish to call it, contains about 30 percent ash. It is being successfully burned.

"The cost of getting it from the point of production to the point of consumption is about 15 cents a ton. The advisability of cleaning that material at the point of consumption for the purpose of increasing the efficiency of the boiler plant is under consideration.

"Our engineer tells me that if we reduce the ash in that fuel 20 percent, we will increase the efficiency of our boilers 30 percent, or thereabout, in round figures. You can readily see should a boiler plant cost you $100,000, and you can increase its efficiency 30 percent by cleaning your coal, you can save a great deal of money, even when the point of consumption is at the point of production. The consuming public generally does not understand this, and where they do understand they are confused as to the method to adopt to give them the best results. The technical engineer or salesman points out the efficiency of their system, the next man points out the efficiency of his system, and they get mixed to the point where it is hard to make a decision for fear they make a mistake. Those who are interested wish to get the best that there is on the market.

"I wish to cite a company which, in the last six years since the dry cleaning of coal has become such a factor in the United States, has shipped 15,000,000 tons of coal which contained 3 percent of ash that could have been removed at the mine. Therefore, they have shipped 3 percent of 15,000,000 tons, which is about 150,000 tons, of ash or refuse on which they have paid $3.12 a ton freight. Now you can calculate that for yourselves, gentlemen, and to make it easy just figure the freight on this 150,000 tons at an even $3, and you will find you have got enough money to establish any kind of a cleaning plant and discard it every four or five years.

"I would say to everybody in the coal business that coal cleaning has come to stay. One of the reasons for the depression in the coal business in England today is lack of progress in mechanical mining and dry coal cleaning. However, I am pleased to say that the English, who have been washing coal for 75 years (I looked that matter up some four or five years ago, when I had a paper before the Iron & Steel Institute of New York, so I believe at the present time it must be 80 years since the first washes were established in England), are now adopting the dry method, and at the present time the Berkley Iron Co. who are the agents of the American Coal Cleaning Corporation, have six or eight plants in operation, and two or three under construction in England. Now the English, with 75 years' experience, did not, nor has anyone else, successfully washed fine coal for the reason that fine coal absorbs too much water, and where it has to be shipped or where the water has to be evaporated the freight and evaporation cost is too great. A ton of water weighs just as much as a ton of coal, and if you would add 5 percent water or 3 percent water to your coal in West Virginia and ship it to Chicago, the cost for freight would be just as great on the 3 percent water as on the 3 percent dirt.

"I have conducted personal experiments numerous times in our laboratory as to the amount of water that our coal would contain when it got to the scales, and we found that after passing through the best mechanical dryers it would contain sufficient water at the scales to overcome the amount of refuse that we had taken out.

"Now, as some of the papers have illustrated today, where you are figuring on coal that has 15 and 20 percent refuse in it and where you had cleaned it down to 10, 12 or 15 percent, which made it satisfactory to the market, a small percentage of water in that condition doesn't amount to very much. But where you have a coal, as we have in West Virginia, the inherent ash of which is about 4 percent, and we have to ship it long distances and pay high freight rates, we find that it is profitable and advisable—in fact almost imperative—that we take the inerts out down to within 1 or 2 percent of the inherent ash, and this without adding a noncombustible such as water.

"The matter of refuse, inerts and dirt in coal that we have shipped, has for years been an unsolved problem. Our people at the receiving end have been constantly pushing us to 'Clean your coal; give us more carbon in the fuel you send us. Don't send us water; don't send us rock; don't send us dirt; send us carbon.' They say, 'We can not smelt iron with rock. We want fuel.' And that is what every coal consumer in the United States or any other country wants—fuel, not rock. The man who attemps to ship rock or water with his product will lower the reputation of his product in that market. The consumer today has got to the point where he buys his coal practically on analysis. You can't go out to a large company today and sell them fine bituminous coal with water in it, particularly for use in by-product coke ovens."

***ANDREW C. RAMSAY**, of the Coal, Coke & Chemical Corporation*, of Birmingham, Ala., in commenting on coal flotation and methods of separation of coal from refuse, said:

"You all heard Colonel O'Toole talking about cleaning coal. I am not going to expound on that at all. You all know you have to have clean coal. The steel people are asking for it now, have in the past, and always will be. I am connected with the Newcastle Coal Co., of Birmingham, Ala.

"The float on our settling tank, which we were losing, contains 4 ounces of fine coal to a gallon of water. When I say float I mean dust, say from 100-mesh down and finer. Mr. Arzinger has a flotation process, and when I heard of him I asked him to come in and experiment on us, as we wanted to save this fine coal. I am going to say nothing about the coal that goes to the dump from one-quarter of an inch on down which we are losing through the washer. I am going to say nothing about anything but the float in the waste water. I asked him to make experiments on the waste water and show me what he could do. He took a bucket with some oil—a small amount—put in the waste water, and formed a froth and this fine coal came up, surprisingly to me. It looked to me as if more came out than was put in. On the strength of that we put in one cell. We take the waste water, which is 9,000 gallons per hour, or a little over 2,000 pounds of fine coal of 100-mesh and under, which we were losing, and pass it through a pump into this cell. When it comes out we get 8 tons of this fine coal a day that we are saving. Otherwise it was going to the dump. We are selling this to the foundry men and they use it for facing.

"If we had not had this process we could not have recovered it at all. I say this with all my experience with coal washings—20 or 25 years—you can not save it; you lose it. All of the washer men say so. The experience I have had is that we lose it. But with this flotation process we are saving what you can save, what you get out of mother earth, and it is money in our pocket. What goes out on the dump and burns is money lost. Mr. Arzinger is here. I would not attempt to go into the process and explain it; it is the most simple thing you ever saw in your life, and I am not going to say anything about that, as it is over my head.

"Mr. Kelly will attest to what I say: Mr. Arzinger made a test on his coal for the Humphreys Coal Co. in Greensburg, my old home. He took a bucket and put the coal in, which was a quarter of an inch and under, and he formed a froth that came up and scooped the coal out, and they were surprised. When I say surprised I mean this: That all of it came out in one operation, the fine dust, the coal up to a quarter inch, all came up together. You can't do that with your tables and with the other processes.

"As you all know, the most efficient way to wash coal is to size it before you wash it, and the washer will do the best on one size and not all sizes. The tables will do the same thing. This thing is going one step further. It is taking what you are losing with the washers and your tables and recovering it; that is, actually having results.

"Mr. Kelly asked me if I would make a short talk and tell you what has actually happened with us. I can't say anything more. It is actually there and I have seen it with my own eyes. I see it every day—8 tons of this fine coal that we could not save otherwise, coming in and money going into our pockets."

FUNDAMENTALS OF COAL CLEANING

(*Continued from page* 548)

that is in itself saleable, unless it is mixed with some of the lighter gravity products.

Climatic Conditions

To a certain extent, climatic conditions have some influence in the choice of a process and in design. For instance, in Alberta practically all of the cleaning plants are using air methods, this being largely due to the extremely cold winters and the difficulties involved in handling wet washed coal in these climates. However, there is a plant at Corbin, B. C., operating under the same climatic conditions using a wet washing process and heat drying the fines before shipping. In certain regions of the West where there is no surplus of water it would be very natural to favor the dry process solely on this account.

Available Mill Site

The influence of a mill site is not as pronounced in coal cleaning as in metal practice where at times it is a most important factor. The applicability of this factor to coal is only in cases where available level ground is very limited and hence it may be more desirable to use the most compact type of plant possible even at the expense of other features.

Cost of Plant

On account of many variables involved it is very difficult to make any definite comparison on the cost of a cleaning plant. The principal elements are:

First—Conveying of the coal to the plant—storage, if any—the disposal of refuse.

Second—The actual cleaning machinery.

Third—The structure.

Very often the necessary conveying equipment will vary so much that it makes it almost impossible to compare the final costs of completed plants. In some cases this element may equal if not exceed the cost of the cleaning machinery proper and naturally in such cases it would seem advisable to only consider the most efficient type of plant. The cost of the actual cleaning machinery should be more or less comparable in different plants depending on the quality of the coal produced. The variation on the type of building selected is again so great that it can hardly be considered in comparing the cost of different cleaning plants excepting possibly on the basis of the number of square or cubic feet per ton of hourly capacity. My only purpose in mentioning these various elements is to point out the inherent difficulties in making any comparison in the cost of different plants unless one is in possession of the detailed figures to show the cost of the various elements.

In conclusion, I would like to remark that while many of the topics treated in this paper may seem rather elementary, yet at the same time it does seem that there is a very real need for more exact definition of the various elements of which we speak when discussing the coal cleaning problem.

***ANDREWS ALLEN**, Allen & Garcia Co.*, in discussing Mr. Morrow's paper, said:

"There seems to be no very standard practice as to what items should enter into the cost. In our own practice we figure a certain capital charge as a part of the operating cost. We figure the amortization of the plant, but we do not figure the interest on the investment, believing that this is a capital return and depends possibly more on the financing of the plant than upon the actual operation, while the amortization is a function of the operation, the kind of plant, and the manner in which it should be charged off in a certain number of years. Now if we understand that the operating cost of 12 cents or 20 cents includes certain capital charges or does not include them, we will be able to compare. In my experience I have always had the greatest difficulty in comparing operating costs, because they are made up in such various ways. A little standardization in our understanding of operating costs would help a lot.

"As regards the cost of coal, basing it on any agreed standard of accounting, I have recently prepared a curve in a certain case where we have shown the cost of coal of different ash contents; for instance, we had a coal that ran approximately 10 percent ash in the raw. A study of the coal established the fact that it could be cleaned down to 6 percent ash. Would it pay to clean to 6 percent ash? To answer this question our curve was prepared showing the cost of cleaning to 6 percent ash, 6½ percent, 7 percent, 7½ percent, and 8 percent ash coal. With this data at hand, and with a plant sufficiently elastic to enable one to vary his ash according to sales requirements, one can very quickly determine the amount of cleaning which it is economical to do under any conditions.

"With a given feed your losses increase as the ash content of the washed coal decreases; the quality of the refuse also goes down, and then another question arises as to whether, in case you are cleaning to a low ash percentage, it may not pay to make a second-grade product, a middling which may have a local market.

"Of course, a coal having high ash will not have a very large commercial radius. It can't be sold against a high freight rate over a large area, but very frequently a low-grade fuel will have a local market which will more than pay for the labor of making it and which will enable you to prepare a very high-grade product for the highest class use."

CLEANING COAL AT VON STORCH COLLIERY

(*Continued from page* 562)

would be fully warranted in making use of the Chance flotation process. However, I do not want to be misunderstood and create the impression that this process is absolutely "fool-proof" and 100 percent satisfactory. In fairness to the process, however, it is only 6 or 7 years old and only during the past 3 or 4 years have a substantial number of plants been in operation. Like all new mechanical devices it is necessary to make slight changes in the design and as a result of actual operating experience, improvements have been made with the result that better operating performance is obtained each year. The operation of the plant—while requiring a small force—must be in the hands of men thoroughly trained in the use and applicaton of this method of preparing coal to obtain uniformly satisfactory results.

The management of this company is also affiliated with other companies and now has in operation four of these plants, having an annual production of one and one-half to two million tons per year. Last year these plants operated as a whole a larger percentage of time than any other group of companies in the anthracite field.

***W. H. LESSER**, Madeira, Hill & Co.*, discussed Mr. Steele's paper, saying:

"In discussing Mr. Steele's paper I thought it might be interesting for you men to know what results the Madeira, Hill & Company has obtained from a similar plant. This plant of the Colonial Colliery Company was described a year ago before the meeting of the Mining Congress. Since then we have had sufficient time to study the operation of the system, we have had time to determine if good judgment was used in selecting the system, and finally we are in position to know if the system is capable of satisfactory operating results. The longer we operate the plant, the more we feel that no mistake was made in the selection of the sand flotation process. We have reached a tonnage of 70,000 tons per month, and are satisfied with the three important elements entering into the washing of coal, namely, the quality of the coal shipped, the quality of the refuse, and the cost.

"Purveyors of merchandise to European royalty today have nothing on the purveyor of anthracite coal to the fickle public. They want coal without any slate. We ship from the Colonial Colliery a product which we think is as good as any coal shipped from the anthracite region.

"On account of the quality of coal shipped, Colonial Colliery has worked, during the year 1927, a total of 291 days, while many of the adjoining collierics possibly worked 60 to 70 percent of the time.

"There is no question but that the good quality of the coal shipped has something to do with the enviable position of our operating time. In times of super-preparation, very often, the quality of the refuse improves; that is, more coal finds its way to the refuse bank. During 1927 our refuse bank averaged from 2 to 3 percent of coal, and this included the chipped coal.

"The cost of preparation during 1927 was 29 cents per ton, which included various items. It is not comparable with the costs at Von Storch. This cost includes the coal inspectors; it includes the men on the refuse disposal system, and the four men dumping the coal into the breaker. These men have long bars, and they dig the wet coal from the bottom of the mine cars. It includes also the men running and cleaning the railroad cars.

"I don't know what further remarks to make in relation to Mr. Steele's paper. In looking over some of his figures, for instance, his car yield. Our car yield is about the same as his car yield, 2.66 tons per 100 cu. ft. car. The big point I want to stress about the sand flotation prccess as we use it, or have it in operation at the Colonial Colliery, is that it gives a coal of a very good quality and it satisfies the consumers."

National Photo.

Shaft in Washington, D.C., honoring the First Division in the World War

LEGISLATIVE REVIEW

Congress In Recess Until December—Measures Of Importance To Mining Become Laws—Tax Revision Measure Enacted Into Law—Nearly 700 Public Laws Enacted

THE first session of the Seventieth Congress, which convened in December, 1927, ended on May 29, 1928. During that time 690 public laws were passed and approved by the President. These laws were sifted out of the huge mass of legislative proposals which had been advanced. Nearly 20,000 bills were introduced in the Senate and House during the last six months. The record of bills and documents before both Houses is as follows:

Senate—4,600 bills introduced; 259 resolutions; 164 joint resolutions; 22 concurrent resolutions; 1,326 reports by committees; 170 documents published.

House of Representatives—14,143 bills introduced; 326 joint resolutions; 237 resolutions; 43 concurrent resolutions; 1,927 reports by committees; 327 documents.

Bills pending when the last session closed are subject to consideration at the second session beginning next December. Both Senate and House calendars include a number of measures which are likely to receive attention when Congress reassembles. The bill for power development on the Colorado River is the unfinished business of the Senate, and after its disposition the Senate plans to consider a bill already passed by the House to subject to state laws goods mined or produced by convict labor. Other bills on the Senate calendar are the following: Creating a division of safety in the Department of Labor; limiting the issuance by courts of injunctions in labor disputes; and removing the jurisdiction of the Interstate Commerce Commission over extensions to or abandonment of railroad lines wholly within a State.

The House of Representatives cleaned up most of its pending important bills before the session closed, and the new legislative program will not be taken up until early in the next session. Bills on the House calendar which are subject to consideration when Congress meets again include the following:

Authorizing the Interior Department to grant certain oil and gas prospecting permits and leases in Wyoming; for permits and leases to asphalt and gilsonite on public lands; creating a division of safety in the Department of Labor; permitting war mineral claimants to appeal to the Court of Claims; authorizing railroad consolidations; to grant patents to lands held under claim or color of title for more than 20 years; and to establish an assay office at Dahlonega, Ga.

In addition, all bills pending before congressional committees are subject to action until the Seventieth Congress ends on March 4, 1929. Various committees and commissions of Congress will conduct investigations during the recess. The House Committee on Immigration will endeavor to dispose of 150 pending bills before it. It plans to codify the immigration act and to prepare proposed legislation affecting the naturalization of aliens. The Joint Congressional Committee on Internal Revenue Taxation will also continue to function. One of the subjects it will study will be the percentage depletion rate to be applied to metal mines. The Joint Congressional Committee on Investigation of Land Grants to the Northern Pacific Railroad will also continue its work, which will be devoted chiefly to determination of action which the Government might take in adjusting the land grant on account of alleged erroneous classification of mineral lands. A special committee of the House will look into the matter of employment for prisoners and the effect on free labor of the sale of prison-made goods. The Senate Labor Committee will investigate the unemployment situation.

The session of Congress just closed marked the enactment of several measures of special interest to the mining industry. Of chief importance was the tax revision bill, which reduces the tax rate on corporations by 1½ percent. A law was enacted prohibiting prospectors and miners from killing game for food in the Mount McKinley National Park of Alaska, but continuing the right to

prospect for minerals in the area. Congress passed a law inviting the States and foreign countries to participate in an international petroleum exposition at Tulsa next October. A bill was passed by Congress for Government operation of the power and nitrate project at Muscle Shoals, Alabama, but the President allowed the bill to die by a pocket veto. He did this by neither approving nor disapproving the bill within 10 days after the session ended, which had the effect of killing the measure.

The following is the status of bills as acted on by Congress at the close of the session:

Potash Research

H. R. 496. This bill authorizes appropriations of $200,000, spread over a period of four years, for chemical engineering and manufacturing research for the purpose of determining more improved methods and cheaper processes for recovering potash from potash-bearing deposits in the United States. The work would be conducted by the Bureau of Mines of the Department of Commerce and the Bureau of Soils of the Department of Agriculture. Passed by the House.

H. R. 10885. This bill amends the leasing law regarding sodium by fixing the Government royalties under the leases at 2 percent of the quantity or gross value of the output, instead of one-eighth of the value as fixed by the present law. Passed by the Senate and House.

H. R. 14131. Mr. Timberlake (Rep., Colo.). This bill amends the war mineral relief act by authorizing the payment of losses on account of purchase of property and interest on borrowed capital. Mines and Mining.

The Senate passed a resolution introduced by Mr. George (Dem., Ga.), requesting the Secretary of the Interior to furnish the Senate with copies of rules and regulations followed in the administration of the war mineral relief act, and opinions as to legal points rendered by commissions, solicitors of the Interior Department, and the Attorney General. The resolution was based on the fact that the Attorney General had advised the Secretary of the Interior against further administration of the act and that claimants were demanding adjustment of their cases. Passed by the Senate.

H. R. 393. This bill provides for the taking of a census in 1930 of mines, distribution, population, etc., and each 10 years thereafter. Passed by the House.

S. 4135. This bill withdraws 7,000 acres of public land in the Angeles National Forest from location and entry under the mining laws for the purpose of conserving water and forest resources in Los Angeles County, Calif. Enacted into law.

S. 2328. This bill authorizes stock grazing in national forests, but provides that it shall not prevent the use of coal and other deposits by miners and prospectors. Reported by Senate Committee on Agriculture.

S. 3949. This bill provides that the withdrawal from entry of land for stock-watering purposes shall not have the effect of withdrawing deposits of coal and other minerals. Such minerals shall continue to be subject to location and entry under the mining laws. Passed by the Senate.

H. R. 7937. This bill authorizes the War Department to secure the assistance of the Geological Survey in making military maps and surveys. Enacted into law.

Coal Commission

H. R. 13880. Mr. Rathbone (Rep., Ill.). This bill is similar to that previously introduced by Senator Watson (Rep., Ind.), creating a bituminous coal commission. Interstate Commerce.

S. Res. 249. This resolution appropriates an additional $10,000 for the expenses of the investigation of the coal industry conducted by the Senate Interstate Commerce Committee. The Senate had previously appropriated $10,000 for this purpose. Passed by the Senate.

H. R. 12451. This bill proposes to establish an assay office at Dahlonega, Ga. It provides $5,000 for its equipment and $5,000 annually for its expenses, including rent of building, expenses, and salaries of officials. Reported by House Coinage Committee.

S. 4549. Mr. George (Dem., Ga.). This is similar to the foregoing. Mines and Mining.

H. R. 13998. Mr. Welch (Rep., Calif.). This bill proposes to cover present assayers of mints and assay offices into the classified civil service, without examination, and that hereafter assayers shall be appointed under civil-service laws. Civil Service.

S. Res. 95. This resolution proposes to authorize the Senate Mines and Mining Committee to revise down to date and republish previous reports of the Senate Gold and Silver Commission on foreign exchange and European currency and finance. It was estimated the expense would be $17,000, and that it would take six months to do the work. Reported by Senate Mines and Mining Committee and referred to Expenses Committee.

H. R. 14032. Mr. Britten (Rep., Ill.). This bill authorizes the Smithsonian Institution to investigate and report to Congress on the advisability of the purchase by the Government and exhibition in the Institution of the collection of coins of the late V. M. Brand. Library Committee.

H. R. 13070. Mr. Foss (Rep., Mass.). This bill amends section 3583 of the Revised Statutes regarding counterfeiting of coins to read as follows: "No person shall make, issue, circulate, or pay out any note, memorandum, token, or other obligation for a less sum than $1, intended to circulate as money or to be received or used in lieu of lawful money of the United States; and every person so offending shall be fined not more than $500 or imprisoned for not more than 6 months, or both." Judiciary.

Mine School

H. R. 10157. This bill authorizes a grant of 100,000 acres of land to the Alaskan School of Mines and Agricultural College. The land will be sold for not less than $5 per acre at public auction, or it may be leased. Proceeds of sales and leases will go to the institution. Passed by the House.

H. R. 8126. This bill prohibits the killing of game for food purposes by prospectors and miners in the Mount McKinley National Park in Alaska. The right to prospect for minerals within the park will continue as before. Enacted into law.

S. 1512. This bill provides for contests of oil and gas permits. It reads as follows:

"That if any person qualified to receive an oil and gas prospecting permit under the leasing act contests an oil and gas prospecting permit and procures a cancellation of such permit, the contestant shall be notified of such cancellation by the Secretary of the Interior and shall, during the period of 30 days from the date of such notice, be entitled to a preference right over others to an oil and gas prospecting permit for the lands included in such canceled permit.

"If any person who has initiated a contest dies before the termination thereof, such contest shall not abate, but the heirs of such person who are citizens of the United States may continue the prosecution of such contest under such rules and regulations as the Secretary of the Interior may prescribe, and such heirs shall be entitled to the same rights under this act that the contestant would have been entitled to if his death had not occurred.

"The Secretary of the Interior is authorized to make such rules and regulations as he may deem necessary to carry out the provisions of this act." Passed by the Senate.

Oil Exposition

H. J. Res. 292. This resolution authorizes the President to invite the States and foreign countries to participate in an international petroleum exposition at Tulsa, Okla., beginning October 20. Enacted into law.

H. R. 8529. This bill authorizes the Court of Claims to determine questions of law involved in the erroneous collec-

tion of tonnage taxes of $60,283 in 1920 and 1921 on three vessels operated by the Standard Oil Co. of New Jersey under charter. Passed by the Senate.

S. 4354. Mr. Reed (Rep., Pa.). This bill permits the Atlantic Refining Co. of Pennsylvania to sue the Government in the court for the eastern district of Pennsylvania for damages to one of its vessels by a Government battleship in the Delaware River in 1921. Claims.

H. R. 13589. Mr. Welch (Rep., Pa.). This bill is similar to the foregoing. Claims.

H. R. 11134. This bill authorizes the construction of gasoline and oil storage facilities at various Army posts. Enacted into law.

S. Res. 252. Mr. Nye (Rep., N. Dak.). This resolution requested the President to direct Government counsel to prosecute bribery indictments against E. L. Doheny and A. B. Fall growing out of the naval oil reserve leases.

S. 3365. This bill authorizes mining leases on lands of the Indians on the Shoshone or Wind River Reservation in Wyoming. Enacted into law.

S. 3594. This bill extends the restrictions on the lands of the Five Civilized Tribes of Indians in Oklahoma for 25 years from April 26, 1931, and subjects minerals produced after that date on the lands to State and Federal taxation. Enacted into law.

S.4448. This bill subjects to taxation by Oklahoma lands of the Five Civilized Tribes in excess of 160 acres after April 26, 1931. Enacted into law.

Coal Leases

S. 3867. This bill extends existing developed mining leases to coal and asphalt lands of the Choctaw and Chickasaw Indians, and the time for their payment, until September 25, 1932. Enacted into law.

S. 3593. This bill authorizes the lease or sale of lands reserved for administrative purposes for the Fort Peck, Montana, Indians. Enacted into law.

S. 2360. This bill authorizes the Interior Department to reduce the area to be offered annually or to suspend leases for not more than two years on the Osage Indian Reservation at times of overproduction of oil or inadequate prices. The entire area must be leased, however, not later than April 8, 1936. Passed by the Senate.

H. R. 1. This is the new tax reduction bill, effective on incomes for 1928 to be reported on returns in 1929. It makes a total tax reduction of $225,295,000. The corporation tax is reduced from 13½ percent to 12 percent, a total reduction of $123,450,000. Corporation taxes are further reduced $12,000,000 as the exemption on corporations having net income of not more than $25,000 is increased from $2,000 to $3,000. The bill allows depreciation and depletion to life tenants of property. Enacted into law.

S. Res. 235. This resolution requested the Joint Committee on Internal Revenue Taxation to report concerning taxes and penalties collected as a result of disclosures by the Senate Public Lands Committee in its investigation of the naval oil reserve leases. The resolution was passed by the Senate and the report made.

Land Title

S. 3776. This bill authorizes patents to land held under claim or color of title for more than 20 years upon the payment of $1.25 per acre. Passed by the Senate and reported by the House Committee on Public Lands.

H. R. 13899. Mr. Michener (Rep., Mich.). This bill is similar to the foregoing, except that it applies only to public land in Michigan, and restricts the acreage to be patented to each person to 160 acres. Public Lands.

H. J. Res. 318. This resolution directs the Interior Department to withhold approval of adjustment of the land grant to the Northern Pacific Railroad until June 30, 1929. It also authorizes the Joint Congressional Committee which has been investigating the grant to report on the matter at any time. Enacted into law.

S. Res. 237. This resolution provides for an investigation by the Senate Public Lands Committee as to the establishment of additional national parks and proposed changes in and boundary revisions of other national parks. Passed by the Senate.

S. Res. 239. This resolution provides for an investigation by the Senate Agricultural Committee of public lands adjacent to waters in northern Minnesota for forest purposes, including the withdrawal from entry of public lands. Passed by the Senate.

S. J. Res. 46. This resolution provided for Government operation of the nitrate and power project at Muscle Shoals, Alabama. It was passed by both House and Senate, but failed of enactment into law because the President neither signed nor vetoed it within 10 days after the close of the session of Congress. Under the Constitution, this operated as a pocket veto of the measure.

S. J. Res. 164. This resolution authorizes the Secretary of Interior to appoint five eminent engineers and geologists, one of them an Army engineer, to report before December 1 as to matters affecting the safety, economic and engineering feasibility, and adequacy of the proposed structure and works involved in the Colorado River development project. Enacted into law.

H. R. 5773. This bill provides for power development on the Colorado River. Passed by the House.

H. R. 5746. This bill provides for the sale to the contractor of the plant furnishing electricity to the naval ordnance plant at Charleston, W. Va. Enacted into law.

H. J. Res. 243. This resolution provides for the issuance of a $1,000 gold medal to Thomas A. Edison in recognition of his achievements in electrical developments. Enacted into law.

H. R. 7938. This bill provides that in operating any utility under the War Department under which services or supplies are sold, the cost of the services or supplies sold shall include all overhead costs of labor, rent, light, heat, and other expenses chargeable to the conduct of the utility. Passed by the House.

H. R. 13484. This bill provides for a report by the War Department on methods to remove the sources of pollution of the west branch of the Susquehanna River in Pennsylvania and the Auglaize, Blanchard and Ottawa Rivers in Ohio. Passed by the House.

Steel Cars

S. 2107. This bill provides that steel cars shall be used in the railroad postal service after March, 1930. Passed by the Senate.

S. 2309. This bill removes the authority of the Interstate Commerce Commission over the construction of new lines or extension of existing lines of railroads wholly within a State, if the laws of the State require a certificate of public convenience or necessity therefor. Reported by the Senate Interstate Commerce Committee.

S. 4460. Mr. Brookhart (Rep., Iowa). This bill authorizes the Interstate Commerce Commission to acquire and provide for the operation of a coast-to-coast railroad. Interstate Commerce.

H. J. Res. 321. Mr. Hill (Dem., Wash.). This bill would permit the Cascade Tunnel Association to enter lands belonging to the Government for the purpose of constructing a tunnel under the Cascade Mountains in the State of Washington. The terminal points of the tunnel would be near the towns of Skykomish and Leavenworth. The tunnel would run through a forest reserve from King County on the east to Chelan County on the west. The tunnel would be a low-level type for general transportation purposes. Public Lands.

H. J. Res. 322. Mr. Hadley (Rep., Wash.); S. J. Res. 165, Mr. Dill (Dem., Wash.). These resolutions are similar to the foregoing. The House resolution was referred to the Public Lands Committee and the Senate resolution to the Agricultural Committee.

S. 4552. Mr. Gillett (Rep., Mass.). This bill directs the War Department to conduct an examination of the Cape Cod

Canal in Massachusetts with a view of improving it to accommodate present and prospective commerce. Commerce.

S. Res. 220. This resolution provides for investigation and report at the next session by the Secretaries of State and Agriculture, the Shipping Board and the Interstate Commerce Commission as to the diversion of commerce from American ports to Canadian ports, and measures which may be taken to restore the commerce of American ports. Passed by the Senate.

H. R. 13790. Mr. Welch (Rep., Calif.). This bill, which is similar to one previously introduced by Senator Reed (Rep., Pa.), proposes to promote labor and industry in the United States by expanding in the foreign field the service now rendered by the Department of Labor in securing and distributing information regarding labor and industry. Labor.

Court Injunctions

S. 1482. This is a new draft of a measure to define and limit the jurisdiction of courts in issuing injunctions in labor disputes. The bill was drafted by a subcommittee and is now before the Judiciary Committee of the Senate. Under the bill, contracts or agreements not to join, become, or remain a member of any labor or employer organizations, or providing for withdrawal from employment relation in event that the parties become members of labor or employer organizations, shall not be enforced by court action. Courts shall not have jurisdiction to restrain or enjoin the following acts involved in a labor dispute; ceasing or refusing to work; becoming or remaining a member of labor or employer organizations; paying or withholding from persons participating and interested in labor disputes, of strike or unemployment benefits or insurance; aiding persons participating in labor disputes; publicity in labor disputes by advertising, speaking, patrolling, or other methods not involving fraud or violence; peaceable assembly in promoting interests in a labor dispute; advising persons of intention to do any of the foregoing acts; agreeing with other persons to do or not to do any of the foregoing acts; advising, urging or otherwise causing or inducing without fraud or violence the foregoing acts. Courts will not have jurisdiction to issue restraining orders or injunctions on the ground that any other parties participating or interested in a labor dispute constitute or are engaged in an unlawful combination or conspiracy because of the performance in concert of the foregoing acts. Officers or members of any association or organization, and associations or organizations participating in labor disputes shall not be held responsible for the unlawful acts of individual officers, members or agents except upon such clear proof of actual participation, authorization or ratification of such acts after actual knowledge. Injunctions in labor disputes will be issued only on testimony in open court and a finding that unlawful acts have been committed and will be continued unless restrained; that substantial injury to property will follow; that greater injury will be done to the complainant by denial of relief than will be done to defendants in granting relief; that there is no adequate remedy at law and that public officers charged with protecting property are unable or unwilling to furnish adequate protection. Cases would be promptly appealed and decided by the Circuit Court of Appeals. Persons charged with indirect criminal contempt for violating restraining orders or injunctions would have a speedy trial.

IMPORTANT BILLS REVIEWED IN THIS ISSUE

Mining

H. R. 496—Passed by House. Potash Research.
H. R. 10885—Sodium Royalties. Passed by House and Senate.
H. R. 14131—Timberlake (R., Colo.). War Mineral Claims.
H. R. 393—Mine Census. Passed by House.
H. R. 13880—Rathbone (R., Ill.). Coal Commission.
H. R. 12451—Georgia Assay Office. Reported by Committee.
H. R. 10157—Alaska School of Mines Land Grant. Passed by House.

Oil

S. 1512—Oil and Gas Permit Contests. Passed by Senate.
H. J. Res. 292—Oklahoma Oil Exposition. Enacted into Law.
S. 2360—Lease Suspension. Passed by Senate.

Revenue

H. R. 1—Tax Reduction Bill. Enacted into Law.

Power

S. J. Res. 46—Muscle Shoals Development. Vetoed.
S. J. Res. 164—Colorado River Investigation. Enacted into Law.
H. R. 5773—Colorado River Development. Passed by the House.
H. R. 13484—Stream Pollution Remedies. Passed by House.

Transportation

S. 2107—Steel Cars. Passed by Senate.
S. 2309—Railroad Extensions. Reported by Senate Committee.
H. J. Res. 321—Hill (D., Wash.). Cascade Tunnel.
S. Res. 220—Port Traffic Inquiry. Passed by Senate.

Labor

H. R. 13790—Welch (R., Calif.). Labor Department Investigation Expansion.
S. 1482—Court Injunctions in Labor Disputes. Subcommittee Draft.
H. Res. 233—Investigation of Employment of Prisoners. Passed by House.
S. Res. 219—Unemployment Investigation. Passed by Senate.

Unemployment Inquiry

H. Res. 233. This resolution provides for a committee of five members of the House to investigate the employment of prisoners in Federal and State institutions. The inquiry will cover the kind and amount of goods mined and produced in such institutions, the extent to which they compete with goods produced by free labor. The committee will report the best means by which prison-made goods can be disposed of without such competition. The resolution was passed by the House and the investigation will be conducted by the following: Representatives Cooper (Dem., Ohio); Kopp (Rep., Iowa); Taber (Rep., N. Y.); Bell (Dem., Ga.); and Boylan (Dem., N. Y.).

S. Res. 219. This resolution provides for investigation by the Senate Labor Committee of the unemployment situation, including the effect on employment of curtailed production, consolidations, and economic reconstruction. The committee is to report February 15, 1929. It is allowed $15,000 expenses. Passed by the Senate.

H. R. 13901. Mr. Rathbone (Rep., Ill.). This bill proposes the establishment of a national employment system. It appropriates $4,000,000 per year until June 30, 1932, 75 percent of which shall be allotted to the States for maintaining public employment agencies. Judiciary.

H. R. 12695. This bill authorizes the licensing of patents owned by the United States. Passed by the House.

H. R. 6687. This bill gives the Court of Customs Appeals jurisdiction over patent appeals. Passed by the House and Senate.

H. R. 43. This bill standardizes lime barrels. Passed by the House.

H. R. 5780. This bill proposes to pay claims for additional work performed by employes of the Bethlehem Steel Co. under a Navy contract. Passed by the House.

H. R. 13850. Mr. Kent. (Dem., Pa.). This bill proposes to pay additional compensation to electrical workers of the Bethlehem Steel Co. under an Army contract. Claims.

H. R. 13874. Mr. Bushong (Rep., Pa.). This is similar to the foregoing. Claims.

STATISTICS OF THE COPPER INDUSTRY IN 1927*

THE outsanding features of the copper statistics for 1927, according to the United States Bureau of Mines, were a small decrease in smelter production from domestic ores, virtually no change in refinery production from domestic and foreign ores, a large decrease in imports, a large increase in exports, a decrease in total smelter and refinery stocks, a decrease in average price, and a large drop in domestic withdrawals.

Production of new refined copper from domestic and foreign sources in 1927 made a little over 3,000,000 pounds more copper available for consumption than in 1926, and a drop of 67,000,000 pounds in refined copper imported and an increase of 80,000,000 pounds in refined copper exported, made a difference of 144,000,000 pounds in available supply. Stocks of refined copper were 22,000,000 pounds larger at the beginning of 1927 than at the beginning of 1926, and at the beginning of 1928 were 25,000,000 pounds larger than at the beginning of 1927. Consequently the decrease in domestic withdrawals, 147,000,000 pounds, approximated the decrease in available supply shown above.

Smelter Production

The smelter production of primary copper from domestic sources during 1927 amounted to 1,684,040,983 pounds, a decrease of approximately 3 percent. The value of smelter production decreased approximately 9 percent in 1927. The average price of 2,836,000,000 pounds of copper delivered during the year, as reported to the Bureau of Mines by selling agencies, was 13.1 cents a pound.

In the following table the production is apportioned to the states in which the copper was mined. The figures represent the content of fine copper in the blister produced, the smelter output of ingot, and anode copper from Michigan.

Refined Copper

The total production of new refined copper in 1927 was 2,326,000,000 pounds, an increase of over 3,000,000 pounds over that in 1926.

In addition to their output of metallic copper, the regular refining companies produced bluestone (hydrous copper sulphate) having a copper content of 9,180,000 pounds, as compared with 8,498,000 pounds in 1926.

SUMMARY OF FEATURES OF THE COPPER INDUSTRY IN THE UNITED STATES IN 1926 AND 1927

		1926	1927
Production of copper:			
Smelter output	pounds	1,739,622,094	1,684,040,983
Mine production	do	1,725,275,931	*
Refinery production of new copper:			
Electrolytic	do	1,553,041,424	1,520,076,181
Lake	do	172,372,304	195,135,199
Casting	do	5,883,433	3,740,819
Total domestic	do	1,731,297,161	1,718,952,199
Total domestic and foreign	do	2,322,485,376	2,325,763,709
Total new and old copper	do	3,282,000,000	*
Ore produced:			
Copper ore	short tons	57,181,894	*
Average yield of copper	percent	1.46	*
Copper-lead and copper-zinc ores	short tons	282,015	*
Average price per pound	cents	14.0	13.1
Imports (unmanufactured)	pounds	799,441,808	718,322,990
Exports of metallic copper†	do	960,220,112	1,069,493,121
Withdrawn from total supply on domestic account:			
Total new copper	do	1,570,136,207	1,422,959,219
Total new and old copper	do	2,530,000,000	*
Stocks of refined copper‡	do	146,000,000	171,000,000
Stocks of blister and materials in solution‡	do	455,000,000	401,000,000
Value of smelter production from domestic ores	dollars	243,547,000	220,609,000
World's production (smelter)	pounds	3,192,293,000	*

* Figures not yet available. † Total exports of copper, exclusive of ore, concentrates, composition metal, and unrefined material. ‡ At the end of the year.

Stocks of blister copper on hand at the smelters, in transit to refineries and at refineries, decreased sufficiently so that there were 29,000,000 pounds less copper in total smelter and refinery stocks than at the end of 1926.

COPPER PRODUCED IN THE UNITED STATES FROM DOMESTIC ORES, 1926-1927
(Smelter output, in pounds fine)

State	1926	1927
Alaska	67,631,846	56,489,214
Arizona	729,324,537	681,168,117
California	30,442,961	25,802,608
Colorado	4,657,591	8,006,801
Idaho	1,171,262	1,811,103
Michigan	174,778,884	195,135,199
Missouri	54,378	5,041
Montana	257,271,936	225,208,853
Nevada	109,041,769	118,298,342
New Mexico	82,848,096	79,761,222
North Carolina	1,468,746	5,362,041
Oregon	279,223	484,652
Pennsylvania	495,698	2,149,182
Tennessee	18,601,586	14,498,951
Texas	17,102	25,460
Utah	259,649,158	267,705,597
Vermont	446,323	238,143
Washington	1,336,617	1,766,953
Undistributed	104,381	123,509
	1,739,622,094	1,684,040,983

*A more comprehensive report, entitled "Copper in 1927," is in preparation and will be published by the Bureau as a part of a general review of the production and resources of metals in that year. The brief statement here presented is published in advance of the complete report in response to a demand for official figures at the earliest possible date.

The figures here given are obtained from smelters and refiners and represent the metal actually recovered, in terms of blister and refined copper, from materials treated in 1927. These figures do not exactly correspond with those showing the copper mined during the year. Annual smelter production and mine production, representing different steps in the production of copper, should not be confused as they do not agree precisely.

ASBESTOS IN 1927

THE total quantity of asbestos sold or used by producers in the United States in 1927 was 2,986 short tons, valued at $338,066, according to figures compiled by the United States Bureau of Mines. These figures represent chrysotile asbestos mined in Arizona, and amphibole asbestos mined in Georgia and Maryland. The sales of chrysotile asbestos were much larger, both in quantity and value, than those of 1926, and the sales of amphibole asbestos showed an increase in quantity but a decrease in value.

Imports of unmanufactured asbestos for consumption amounted in 1927 to 223,693 short tons, valued at $8,150,340, and the exports were 309 short tons, valued at $48,774. Corresponding figures for 1926 were: Imports, 257,621 short tons, valued at $8,142,505; exports, 1,104 short tons, valued at $85,922.

SALES OF LIME IN 1927

THE lime sold by producers in the United States in 1927 amounted to 4,337,000 short tons, valued at $38,210,000, according to estimates furnished by lime manufacturers to the United States Bureau of Mines, Department of Commerce. This is a decrease of 5 percent in quantity and 8 percent in value as compared with sales in 1926. The sales of hydrated lime, which are included in these figures, amounted to 1,562,000 tons, valued at $14,300,000, a decrease of 3 percent in quantity and 6 percent in value. The average unit value of all lime showed a decrease from $9.11 a ton in 1926 to $8.81 in 1927, and that of hydrated lime a decrease from $9.45 a ton in 1926 to $9.15 in 1927.

PHOSPHATE ROCK IN 1927

THE total quantity of phosphate rock sold or used by producers in the United States in 1927 was 3,166,102 long tons, valued at $11,234,863, according to figures compiled by the Bureau of Mines from individual reports furnished by producers. The figures for Florida were collected in cooperation with the State Geological Survey. The compilation indicates a decrease of 1 percent in quantity and an increase of 3 percent in value as compared with 1926. The quantity and value, by states, of the various kinds of phosphate rock sold or used by producers in 1927 were as follows:

	Long tons	Value
Florida:		
Hard rock	131,254	$525,016
Land pebble	2,506,166	8,121,146
	2,637,420	$8,646,162
Idaho:		
Western rock	45,260	259,405
Tennessee:		
Blue and brown rock	477,172	2,300,296
Wyoming:		
Western rock	6,250	29,000
	3,166,102	$11,234,863

Newmont Mining Options Verde Extension

The United Verde Extension Mining Company has granted a 30-day option on all of its physical properties to the Newmont Mining Corporation. The option will expire on July 2 unless exercised.

The United Verde Extension will retain its cash and quick assets and continue its corporate existence. The terms of the option call for payment for the property with 60,000 shares of the treasury stock of the Newmont Mining Corporation and this stock will be distributed to the United Verde Extension stockholders. On the basis of recent marked quotations for Newmont stock the consideration amounts to somewhat more than $10,000,000.

Newmont Mining Corporation is both a holding company and an operating concern. Chas. F. Ayers is president and Col. Wm. Boyce Thompson is chairman of the Board of Directors.

Mill Under Construction at Verde Central

The Verde Central Mines, Inc., has begun construction of a 300-ton mill at its property at Jerome, Ariz. The mill will be located a quarter mile from the shaft and ore will be hauled from the shaft to the mill over narrow-gauge tracks.

The ore will be treated by flotation and the concentrates sent to the United Verde Extension smelter at Clemenceau. It is presumed that the copper produced will be marketed by the Calumet and Arizona Mining Company, which owns a controlling interest in the Verde Central Mines.

Bunker Hill Plant Producing 275 Tons of Refined Lead Daily

The Bunker Hill plant at Bradley, near Kellogg, Idaho, is now producing 275 tons of refined lead daily, according to A. F. Beasley, and this production will be continued indefinitely. Seven thousand two hundred tons of concentrates and crude ore will be received this season from the Treadwell-Yukon Company of Alaska.

"Some of this ore carries 60 percent lead and 600 ounces of silver to the ton, and on that account will stand the heavy freight charges of $40 a ton," said Mr. Beasley at a recent meeting of the Spokane Chamber of Commerce Mining Bureau. "This means an output of about 1,000,000 ounces of silver a month from this ore."

Idaho Mine Profits in 1927, $7,000,000

According to statements recently filed at the assessor's office by the mining companies operating in Shoshone County, Idaho, net profits during 1927 approximated $7,057,489, or $900,412 below those of 1926. Fifteen companies operating in the Coeur d'Alene district of northern Idaho reported profits. Bunker Hill & Sullivan ranked first with net earnings listed at $2,632,936. The Hecla Mining Company gave its net at $2,026,600. The Morning mine, owned by the Federal Mining & Smelting Company, ranked third, with a profit amounting to $1,888,569.

Lake Superior Mining Institute To Meet Sept. 7 and 8

The annual meeting of the Lake Superior Mining Institute will be held on the Menominee iron range in upper Michigan September 7 and 8. Members of the institute will convene in Iron River and Crystall Falls, Mich., September 7. The following day they will go to Iron Mountain, where the convention will be held. George Eisele, assistant superintendent of the Oliver Iron Mining Co. on the Menominee range, is general chairman of the committee on arrangements. Engineers and mining officials of national reputation will speak at the convention. The meeting will be the first the institute has held in two years. Members planned to make a trip to Jopuin and southeastern Missouri late in April, but the tour was called off because of insufficient interest.

ANNUAL MEETING OF WESTERN DIVISION, THE AMERICAN MINING CONGRESS

THE Western Division of The American Mining Congress has announced the week of September 10 as the date for its annual meeting to be held at the Biltmore Hotel, Los Angeles, Calif. The Western Section of The American Institute of Mining and Metallurgical Engineers, and the California Development Association will cooperate with the Division, holding sessions during the same week.

The preliminary program, as announced by the committee in charge of arrangements, includes seven sessions, four sessions under the auspices of the Western Division, two under the auspices of the Institute and one session sponsored by the California Development Association.

Two of the sessions sponsored by the Western Division will be devoted to practical operating problems of the mining industry of the West. The program for the convention will be available within a few weeks, and will be one of the most comprehensive yet arranged for the discussion of the problems of the metal industry.

Phillip Wiseman, Los Angeles, Calif., is chairman of the Western Division. The Biltmore Hotel, Los Angeles, Calif., will be the official headquarters of the convention. The committees on arrangement are as follows: *Executive:* Philip Wiseman, Robert R. Boyd, and C. S. Knight. *Finance:* Ward Blackman, chairman. *Publicity:* Edward Higgins, chairman. *Program:* Robert Linton, chairman, and Guy N. Bjorge, secretary. *Institute Committee:* Prof. Jay A. Carpenter, Reno; Prof. W. F. Dietrich, Stanford; Hoyt S. Gale, Los Angeles; A. B. Tucker, Los Angeles; George J. Young, San Francisco; Prof. E. P. Mathewson, Tucson. *Western Division Committee:* J. P. Hodgson, Arizona; Robert Linton, California; J. W. Ady, Colorado; C. W. Newton, Idaho; C. S. Berrian; Montana; J. C. Kinnear, Nevada; R. B. Tempest, New Mexico; A. S. Winther, Oklahoma, and Frank M. Smith, Washington.

American Smelting & Refining Company Acquires El Tiro

The American Smelting & Refining Company has acquired the property of the El Tiro Corporation at Silverbell, Ariz. The El Tiro is now shipping ore at the rate of approximately 100 tons per day to the company's smelter at Hayden.

From 1917 to 1925 the property was in the hands of the Bondholders Committee and was leased by them to the El Tiro Leasing Company, which was organized by Percy Williams and operation was under his direction. In January, 1925, this lease was transferred to the Western America Mines with option to purchase. In 1924 the property was under option to the Calumet and Arizona Mining Company, but this option was surrendered at the end of a 60-day period.

Mining on Mariposa Grant to be Renewed

The Fremont Grant, Inc., has been organized under the laws of Nevada to acquire and operate the mining properties on the Mariposa Grant in Mariposa County, Calif. The Mariposa Grant, obtained in 1856 by Gen. John C. Fremont, comprises approximately 44,000 acres and includes a length of 12 miles of the southerly end of the mother lode. Operations will be in charge of Dwight E. Woodbridge, mining engineer of Duluth, Minn.

It is reported that activities at first will be largely restricted to reopening of the old producers. The mines on the Mariposa Grant have been inactive for many years, but there was at one time a great deal of activity. The more extensive operations were at the Mariposa mine at Mariposa, the Princeton mine at Mount Bullion, the Ophir near Mount Ophir, and the Josephine and Pine Tree near Bagby. The deepest work is at the Princeton, which has reached a depth of 1,600 ft.

Utah-Apex Development

It has been reported that the Utah Apex Mining Co., Bingham, Utah, will develop the Big Hill, Empire mines, Swansea and others in the Tintic district. Plans are said to include the lowering of the Big Hill two-compartment shaft from the 800 to the 2,000-ft. level.

The Section 16 Mine of the Oliver Iron Mining Co., Ishpeming, Mich., which has been down for retimbering of the shaft, is expected to resume production about the middle of July. This mine is one of the largest of the company in the Lake Superior District.

Underground Transportation in Metal Mines

The American Engineering Standards Committee has approved as American Recommended Practice the code for "Underground Transportation in Metal Mines," developed by the Standardization Division of the American Mining Congress and submitted by them as sponsors. The date of approval was May 26, 1928, and the American Engineering Standards Committee designating number is M-18-1928. It is procurable from the A. E. S. C. or the American Mining Congress.

WESTERN REFINERY OF NICHOLS COPPER TO BE AT EL PASO

Formal announcement has been made that the new western copper refinery of the Nichols Copper Company will be erected at El Paso, Tex. A site embracing approximately three hundred acres was taken under option when plans for a western refinery were in a preliminary stage. This option will now be exercised and construction will begin at an early date. It is estimated that the cost of the new plant will approximate $3,000,000.

The Phelps Dodge Corporation, Calumet and Arizona Company and the New Cornelia Copper Company are associated with the Nichols Copper Company in the enterprise.

Michigan Tech Fellowships

Thirty applications for the 12 graduate fellowships which the Michigan College of Mining and Technology at Houghton, Mich., is offering for the academic year 1928-29, have been received. The fellows elected will register as graduate students and become candidates for the degree of Master of Science. The fellowships carry a stipend of $1,200 each. Holders will engage in the study of the various problems in connection with the general research program of the college for which the State of Michigan has provided $50,000 for the coming year. The research program deals with all phases of the iron and copper resources of northern Michigan and their utilization. Appropriate parts of the program are carried on in cooperation with the mining companies and the Bureau of Mines.

Oglebay, Norton to Sink Shaft

Oglebay, Norton & Co. is preparing to sink a shaft at its Palms-Book property southwest of Iron River, Mich., on the Menominee iron range. Work is expected to start about August 1. The property lies west of the Hiawatha mine of the M. A. Hanna Co.

United Trinity Mines Now Operating

The United Trinity Mines, Carrville, Trinity County, Calif., was placed in operation May 1. The direction of this property was recently taken over by V. H. Christenson as engineer in charge and Lloyd Root as chief engineer. The latter has recently returned from an inspection of the property and reports that the 20-stamp mill is running at capacity and that the placer ground should be in operation by the first week of July. Work on the hydroelectric power development is also in progress.

Nevada Accident Benefit Premiums Raised

The Nevada Industrial Commission has notified mining companies that a 40 percent raise in accident benefit premiums will go into effect July 1. The raise has become necessary because the accident insurance department has shown losses for several months.

Great Western Gold Mine to be Developed

The Great Western gold mine, including the old Lincoln Hill mine in the Rochester district, Nevada, has been acquired by Thomas F. Cole and associates and will be developed at depth. A two-compartment shaft will be sunk to test veins that yielded good ore near the surface. The property is equipped with an electric power hoist, compresser and a two-stamp mill. It has in the past been a profitable producer on a small scale.

CALIFORNIA NEWS NOTES

The Plumas Eureka mine, which has lain idle for many years, has four men at work, and New York capitalists have sent their engineers to examine the property with a view to taking it over. With the melting of the snows in Plumas County, many mines are again operating.

A gas well has been brought in by the Milham Exploration Co., operating near Buttonwillow, Kern County, and 20,000,000 cu. ft. daily is reported from this well, which has been drilled to a depth of 2,716 ft. This company now has five wells in the district.

The Halyard Grave property, 7 miles from Camptonville, Yuba County, has a large crew at work and mining operations are being pushed with all posisble speed. The property is owned and operated by the B. F. McNaught Company of Los Angeles. The tunnel is being driven ahead in search of the main channel, which old timers say was one of the best producers in the district.

The Gaston mine and group of claims in the Eureka-Washington District, Nevada County, owned by the Rescue-Eula

Mining Co., one of the well-known mining companies in the county, will be in full operation at an early date. E. E. Schiffner will be in charge of operations. The property has been opened by five tunnels, the lowest of which is 700 ft. long, cutting the vein system about 1,900 ft. deep. The ore averages $6 per ton, and Schiffner estimates the cost of mining and milling at $3.50 per ton. He expects to mill 100 tons per day.

The Drytown Consolidated mine in Amador County, near Drytown, will be reopened and further development work commenced at once, according to Walter Lucot. This is one of the oldest producers on the mother lode but no work has been done on the property for 45 years. Mining men acquainted with this property say the outlook of its becoming a heavy producer are excellent and wonder is expressed that it has lain idle so long. The Silver Dime property, which adjoins the Drytown Consolidated has been devolping for several months past and a two-stamp mill is now installed for treatment of ore from a 10-in. vein of rich ore that is being followed. Owners of both properties are very enthusiastic over present showings.

Los Angeles mining men were in Mariposa County recently completing arrangements to take over, under bond and lease, the "King Midas," or Sweeney mine, at Pittsburg Landing near Mount Bullion. There is a small mill on the property and the shaft is down 100 ft. Charles W. Knight was the former owner of the property. Plans of the new owners have not been made public at this time.

The old Finney mine near Downieville, Sierra County, recently encountered a new vein of ore running from $20 to $30 per ton, according to Manager J. H. Collier, who is in charge of operations. The vein, while only 16 in. wide, was picked up at the footwall and has been followed for some distance. The tunnel is now in 800 ft.

University of Arizona Again Has Summer Field Course in Geology

The University of Arizona, through the Arizona Bureau of Mines, is again offering an eight-week summer course in field geology, which will begin on July 1 and end on August 25. The party was scheduled to leave the university at Tucson by automobile on July 1. The area selected for study lies on the eastern flank of the Patagonia Mountains in southern Arizona. Eleven mining properties, eight of which are now operating, will be available for underground study. The work will include topographic surveying, mapping of areal geology, and a detailed study of the mining geology of the area.

Silver Reef Mines to be Developed by A. S. & R.

Control of the Silver Reef Consolidated Mines Co., in the Silver Reef district of Utah, has passed into the hands of American Smelting & Refining Co.'s mining research department, and it is understood that a three-compartment shaft will be sunk at least 500 feet deep, from which point extensive development and exploration work will be carried on. A mill will be erected at the mine if the development warrants it.

Federal Options B. C. Property

A two-year option for the purchase of control of the property of the Mohawk Mining Co., on Four Mile Mountain, near Smithers, British Columbia, has been taken over by the Federal Mining & Smelting Co.

California Company to Build Mill in Mono County

The Sierra Vista Custom Ore Milling Company has contracted for the construction of a 130-ton combination mill at the Sierra Vista mine, near Benton, Mono County, Calif. The company has a 20-year lease on the mine, the ore averaging $7 in gold, $3 in silver, and $7 in lead to the ton.

Shenandoah-Dives to Build Mill

The Shenandoah-Dives Syndicate, Silverton, Colo., is planning to construct a 100-ton flotation mill and tram this year, with provisions for increasing the capacity to 500 tons should it be necessary. The company has been developing for three years under lease, and has ore ready to justify the erection of the mill.

SILVER PRODUCERS LOSE FIRST ROUND IN SUIT TO COMPEL SILVER PURCHASES

The American Silver Producers' Association have lost their suit in the District of Columbia Supreme Court to require the Government to purchase 15,000,000 ounces of silver at $1 per ounce to complete purchases under the Pittman Act, covering allocation of Pittman Act silver for subsidiary coinage, subsequently revoked by the Treasury Department. Justice Stafford in a 14-page opinion declined to issue a writ of mandamus on the Secretary of the Treasury to purchase this silver, on the ground that the association did not have sufficient interest in the litigation. Justice Stafford stated that the case presented other questions of great importance, but in view of his conclusion as to the right of the parties to maintain the suit, they were not considered by him in disposing of the case.

In his opinion, Justice Stafford stated that the Silver Association is a mere representative of its members and has no direct financial interest in the purchase of silver since it is a non-profit corporation. Referring to the claim of the silver interests of injury by failure of the Government to purchase this silver, the court says a general averment of injury can not avail further than it is supported by facts. The opinion declared that the association has no direct financial interest in the performance of the alleged duties of the Government officials concerned, and that the two mining companies would not be financially benefitted if the writ was issued.

"The association does not have any right to maintain this proceeding at law as the mere agent or representative of its members," said Justice Stafford. The court holds that the interest of the silver litigants is indirect and remote, not to say conjectural and is not such an interest as would entitle them to the writ. Neither have they any special or individual right of interest to maintain the suit. The court doubts whether a corporation has the same general interest in the enforcement of the public laws as a citizen. "Corporations are not citizens in the broad and general sense, but only for certain purposes, for the protection of their own financial interests," says the court. Justice Stafford doubts whether a state corporation can be considered to have been created for the purpose of bringing a suit against high officers of the National Government as a representative of all the people of the United States. He says the silver interests in the suit can not maintain their petition solely in the public interest, without regard to some personal and peculiar interest of their own. As the case fails to show that the litigants have any such interest, he decides that the petition can not be maintained.

The case will be appealed by the silver interests to the Court of Appeals of the District of Columbia. The notice of appeal, which will be made and perfected within the next 30 days, will automatically take the case to the higher court. That court will be asked to pass not only on the decision of Justice Stafford, but on all of the issues of the case. It is expected that the case will be heard by the Court of Appeals in December. An appeal from this court to the United States Supreme Court by either party to the suit would be permissible, but it would be within the right of the United States Supreme Court to decline to review the case.

250-Ton Mill at Big Jim Mines

Plans have been completed for the erection of a 250-ton mill at the Big Jim Mines, Inc., Patagonia, Ariz., according to reports. The present mill has a capacity of 75 tons. The new plant is to be located to permit of the handling of ore from both the Big Jim and the two adjoining properties taken over by Big Jim. Delivery of ore to the mill will probably be by aerial tramways.

Kay Copper to Install First Unit of Large Mill

The immediate installation of a 250-ton unit of a large milling plant is planned by the Kay Copper Company, Canon, Ariz. The mine has been developed to the 1,200 level, with thousands of feet of drifts and crosscuts, blocking out ore bodies, while further extensive exploration has been conducted by means of diamond drilling. It is estimated that 2,000,000 tons of are are available, with an assay value of 5 percent copper.

Report Comstock Merger Mines Sold

It has been reported that a deal has been made whereby New York interests have purchased the properties of the Comstock Merger Mines, Inc., at Virginia City, Nev., including all of the old mines south of the Consolidated Virginia to the Overman and the 10,000-ft. transportation tunnel connecting the mines with American Flat. The properties were closed in December, 1926, when the price of silver dropped to 51 cents, and the 2,500-ton mill sold and dismantled.

Nevada Consolidated Installing 45,000-ft. Water Line

The Nevada Consolidated Copper Co., McGill, Nev., has started the construction of a steel pipe line to replace the wooden water line between Duck Creek and McGill, a distance of 45,000 feet. This pipe will be 37 inches in diameter, capable of carrying 15,750 gallons of water per minute, and will be supported above the ground on concrete piers. The pipe was manufactured in the company's shops at McGill.

Utah Copper Erecting More Homes at Copperton

The Utah Copper Co. has started the construction of 20 additional houses at Copperton, Utah, at the mouth of Bingham Canyon, and when completed will increase the number of residences in the town to 63. Each house represents an expenditure of $5,000. They all have copper-clad roofs and make use of copper wherever possible and practical.

Fire Destroys Ophir Hill Cons. Buildings

Buildings and equipment on the properties of the Ophir Hill Consolidated Mining Co., at Ophir, Utah, were destroyed on the night of June 5, to the extent of about $100,000. The old concentrating mill, which has not been operating since 1925, was destroyed, and the blaze swept the compressor house, ore bins and several smaller buildings, although the mine office, assay office, substation and four residences were not damaged. The losses were partially covered by insurance. The W. A. Clark Estate of Montana owns the property.

Lucky Jim Mill

Production of ore at the Lucky Jim mine, of the Lucky Jim Lead & Zinc Co., in the Slocan district of British Columbia, was resumed recently upon completion of the new concentrator at the property. The new mill has a capacity of 300 tons per day, and is now treating over 200. It is expected that by fall the mill will be operating at capacity.

Grandview Mining Co. Mill

A contract has been let for supplying the steel and machinery for the 1,000-ton milling plant of the Grandview Mining Co., Metaline Falls, Wash. Two million tons of ore, averaging 8 percent zinc, 2 percent lead and 4 ounces of silver to the ton is reported opened up.

The Utah Copper Co. recently filed suit in the Third District Court against Stephen Hays Estate, Inc., and others, seeking to condemn land in the West Mountain mining district, so that the company can recover copper which is held in water solutions on the ground. The company states that it has dumped large quantities of overburden, containing low-grade ore, in Dixon Gulch and Carr Fork canyon. The water washing the ground became saturated with copper and formed pools on the plaintiff's property. The company seeks the condemnation of certain parts of the area on which to build vats and install other equipment for recovering the copper.

"Principles of Valuation"

The recent publication of "PRINCIPLES OF VALUATION," by Prentice-Hall, Inc., 70 Fifth Avenue, New York City, should be of interest to mine owners, investors and engineers. John Alden Grimes and William Horace Craigue, coauthors, are well known to the mining industry as engineers of the Income Tax Unit of the Bureau of Internal Revenue.

This 291-page book deals with the known methods for the valuation of future income. The principal algebraic formulas are not only solved by means of type problems, but are proven by arithmetical tabulations showing the receipt of income and its yearly allocation to the payment of interest and to the return of capital. The tables contain 27,600 valuation factors. They cover rates of interest on investment to 20 percent by increments of 1 percent, and rates of interest from 20 percent to 100 percent by increments of 5 percent, while the tables for use with the Hoskold formula include rates of 3, 4, 5 and 6 percent interest on sinking fund earnings. Various methods by which these tables may be used are indicated by arithmetical problems.

"Principles of Valuation" deals with eight valuation methods: The compound interest deferment method, the compound interest actuarial method, the compound interest sinking fund method, all of which use a single rate of interest; the Hoskold type sinking fund method and the Morkill type sinking fund method, both of which employ two rates of interest; a three interest rate sinking fund method developed by the authors; a commercial modification of the Hoskold method for the mathematically correct means of valuing deferred income at a speculative rate of interest; and, most important of all, the discount for hazard method, which separates the elements of interest on investment and compensation for risk or hazard.

In connection with their discussion of the discount for hazard method, the authors have prepared extensive tables and a series of 12 charts showing the relations of speculative rates of interest to discounts for hazard with respect to each of the commonly used compound interest and sinking fund premises for valuation.

A chapter and an appendix on rates of interest is largely devoted to average annual rates of interest for the safer types of investment over long periods of time. One chart shows several interest rate series in comparison to wholesale commodity prices in the United States, the interest rate series covering the period 1850 to date and, in the case of average yearly rates on the major portion of the interest bearing debt of the United States, from 1802 to date. Other charts and tables give annual rates on total investments of life-insurance companies, farm mortgage rates, rates at New York on commercial paper and collateral time loans, variations in rates of interest according to geographic location and size of community, and numerous other data.

The publishers ask us to state that $10 is the retail price of the book.

U. S. Gold and Silver Product Lower in 1927

Gold production in the United States in 1927 reached an aggregate of 2,197,125 ounces valued at $45,418,600 and the silver output aggregated 60,434,441 ounces valued at $34,266,328, according to a report by the Mint Bureau and the Bureau of Mines.

The reduction in the yield of these metals as compared with 1926 was for gold $2,851,000 and for silver 2,284,305 ounces. In 1915, the year of largest production, gold totaled $101,035,700 and silver 74,961,075 ounces.

California led the states in 1927 in the production of gold, with 564,981 ounces valued at $11,679,200. South Dakota was second with 322,681 ounces valued at $6,680,400 and Colorado, third with 259,111 ounces, valued at $5,356,300. Alaska's production of gold last year totaled 286,298 ounces, valued at $5,198,200.

In silver production last year Utah led with 19,353,758 ounces, valued at $10,973,581. Montana was second with 11,809,765 ounces, valued at $6,696,137 and Idaho third, with 8,928,619 ounces, valued at $5,062,527. Alaska produced 606,129 ounces of silver valued at $343,675.

Tri-State Operators Approve of Clinic

Work of the Tri-State clinic for the past year and the budget for the year beginning July 1 were approved at a meeting of mine operators June 22 at the Picher, Okla., offices of the Tri-State Zinc and Lead Ore Producers' Association.

The financial plan for the coming year will be in substance the same as in the past. The United States Bureau of Mines and the Metropolitan Life Insurance Co. will each pay $8,000, and the mine operators $12,000.

Income from the mine operators last year was more than $5,000 greater than the requirements, and this year will be refunded to the companies who participated in the entire year's work, or credited to their account for the coming year.

Reports were made by the directors, read by J. D. Conover, F. V. Meriwether, clinic director, and A. J. Lanza, chief surgeon of the Metropolitan.

Carson Furnace Patents Upheld

The U. S. District Court of Appeals on May 28 at San Francisco, decided in favor of the Carson Investment Co., representing George R. Carson, in its suit against the Anaconda Copper Mining Co., in which infringement of the Carson reverberatory Carson furnace patents was charged. This decree reverses the decision of the Circuit Court of Butte, Mont.

Deoxidation With Silicon in the Open-Hearth Furnace

One of the primary factors in the rate of elimination of silicates from open-hearth steel is the size of the particle formed on deoxidation. If excess silicon is added to a medium or high-carbon steel, very small, glossy particles are formed which rise slowly out of the steel. On the other hand, if there is sufficient iron oxide or manganese oxide to flux the silica, a rapid increase in rate of elimination is found due to the increased size of the silicate particle.

From the results of laborator work on deoxidation with silicon performed by the Bureau of Mines it is possible to predict just what type of inclusion will be formed with any silicon addition to any type of open-hearth steel, provided manganese is not added at the same time. Predictions from the laboratory work have been checked on various open-hearth heats, and out of 67 steel samples studied only 6 samples showed types different from that predicted. These results make it possible to designate the optimum amount of silicon to add to any open-hearth heat in killing in the furnace, and show that if clean steel is desired certain grades of steel should be killed in the furnace with silicon and manganese rather than silicon alone. Investigation of the properties of the manganese silicates thus formed is now in progress.

Personal Items

Dr. Donald H. McLaughlin, professor of mining at Harvard University, is in Durango, Mexico, on professional work.

Alan B. Calhoun, superintendent of the Bawdwin Mines, Burma, India, is in Minnesota on a six months' vacation.

Thorold E. Field, consulting engineer of Duluth, Minn., and a director of the Roan Antelope Copper Co., has returned from London.

W. E. Smith, secretary of the Cusi Mexicana Mining Co., has been in the Southwest and in Mexico on a business trip.

H. E. Rist, mine foreman at the Christmas Mine, Christmas, Ariz., and formerly with the Iron Cap Copper Co., has gone to Seattle, Wash.

Roland Blanchard, president of the United Metals Corporation, of Duncan, Ariz., has been in New York on business.

John N. Nicol, consulting mining engineer of San Francisco, has been in Oregon on professional work.

P. G. Spilsbury, consulting mining engineer and president of the Arizona Industrial Congress, was married on June 6 to Miss Juanita R. Sears, of Los Angeles.

James E. Fisher, Calumet, Mich., secretary-treasurer of the Calumet & Arizona Mining Co. and the New Cornelia Copper Co., has been elected a director of each of them to fill the vacancy occasioned by the death of George A. Newett, of Ishpeming, Mich.

George S. Goodale, Houghton, Mich., superintendent of the Mayflower-Ole Colony Copper Co. since 1910, has resigned his position to become general superintendent of the Royal Tiger Mines Co., in the Leadville district of Colorado.

E. H. Weitzel, vice president of the Colorado Fuel & Iron Co., will retire July 1 after 21 years of active service with the company.

J. B. Madsen, formerly on the operating staff of the Tonopah Belmont Development Co., has been engaged as mine superintendent for the Oregon Copper Co.

T. S. Davey has resigned as manager for the Kay Copper Corporation and goes to the Alexandria Mines, Inc., of Toronto, Canada. A. L. Richards has succeeded Mr. Davey with the Kay Copper Corporation at Canon, Ariz.

J. Edward Berg, formerly assistant superintendent of the Morning Mine, has been appointed superintendent of the Page Mine of the Federal Mining & Smelting Co., Wallace, Idaho.

Loten Kintz, of the engineering staff at Pilares de Nacozari, Sonora, Mexico, has accepted a position with the Braden Copper Co., in Chile.

Elbert A. Stewart, formerly connected with the United Verde Copper Co., Jerome, Ariz., is now assistant superintendent of the Rochester Silver Corporation, Rochester, Nev.

L. C. Penhoel, president of the Southwest Exploration, accompanied by H. E. Olund, vice president of the Radiore Co., both of Los Angeles, have returned from an extended trip into Mexico.

D. D. Irwin, general superintendent of the Copper Queen Branch, Phelps Dodge Corporation, Bisbee, Ariz., has accepted the general managership of the Roan Antelope Copper Mines of Northern Rhodesia, South Africa. Mr. Irwin has served with Phelps Dodge at its Morenci, Burro Mountain, Moctezuma and Copper Queen branches, covering a term of 16 years.

Eric J. Schrader, Reno, Nev., has been made superintendent for the Gold Circle Consolidated Mines Co., Minas, Nev., to fill the vacancy made by the resignation of Superintendent W. H. Englebright. Mr. Englebright has accepted a position as field engineer with the Sheritt-Gordon Co., Toronto, Canada.

Charles E. Sharpless has resigned his position as chief engineer for J. H. Weaver and associated companies, among which are the Monroe Coal Company and the Heisley Coal Mining Company and will be connected with these interests in a consulting capacity only. Mr. Sharpless will establish an engineering office in Ebensburg, Pa., and confine himself to consultant work.

J. G. Bradley, president of the Elk River Coal and Lumber Co., and president of The American Mining Congress, and Louis S. Cates, general manager of the Utah Copper Co., and former president of the Mining Congress, were two of the prominent mining men who were delegates at the Republican National Convention in Kansas City.

Edward Steidle, instructor in mining at the Carnegie Institute of Technology, Pittsburgh, has accepted the deanship of the School of Mines and Metallurgy at Penn State College. The office at State College was vacated last year, when Dean E. A. Holbrook resigned to become dean of engineering and mining at the University of Pittsburgh.

Samuel D. Warriner, president of the Lehigh Coal & Navigation Company, was honored with the degree of doctor of engineering by Lehigh University at its annual commencement recently.

Martin Gallagher and L. E. Brunswick, division superintendents of the Wheeling & Lake Erie Coal Company, have resigned to take positions with the Pennsylvania Coal Company at Scranton, Pa.

L. F. Quigg has been appointed general superintendent of the Minnequa Works of the Colorado Fuel & Iron Company, succeeding H. B. Carpenter, who has resigned.

Walter C. Teagle, president of the Standard Oil Company of New Jersey, has been elected a director of the Consolidation Coal Company.

W. M. Wiley, vice president and general manager of the Boone County Coal Corporation, Sharpless, W. Va., has been elected a director of the U. S. Chamber of Commerce.

Hal E. Booth, for many years manager of the bituminous coal mines of the M. A. Hanna Company, Cleveland, has been made vice president in charge of sales of the Pittsburgh Coal Company, Pittsburgh.

Walter Barnum, president of the Pacific Coast Company and former president of the National Coal Association, and Mrs. Barnum returned the latter part of May from a sojourn of several weeks in Europe.

W. H. Lyons, of Lexington, Ky., was named president of the American Institute of Mine Inspectors at the recent annual meeting in Lexington. Mr. Lyons is chief of the Kentucky Department of Mines.

John R. Sharp has been appointed as general superintendent of the Bast Colliery, Ashland, and other operations in its vicinity of the Philadelphia & Reading Coal & Iron Company, for the purpose of relieving L. D. Lamont, of Pottsville, and F. C. Caldwell, of Shamokin, of a portion of their duties.

J. W. Powell, consulting mining engineer of Welch, W. Va., sailed on the S. S. *Thuringia* June 14 for Hamburg, Germany, en route via Berlin and Warsaw to Moscow, where he will remain for some time and then go on to Kemerova, Siberia, the headquarters of the Kuzbass Enterprise, which controls three groups of coal mines in the Kuznetz coal basin. Mr. Powell has been connected with the Kuzbass as a consulting engineer since 1924.

I. C. C. Approves Lake Cargo Cut By Northern Roads

Reduced rates on lake cargo coal shipments from Ohio, Pennsylvania and Northern West Virginia points to Lake Erie ports, proposed by the Pennsylvania, New York Central and associated railroads, has been allowed by the Interstate Commerce Commission, and went into effect June 18.

The reduction was proposed by the Northern railroads in their contest with Southern railroads over the lake cargo traffic.

The prolonged fight over these rates has been brought before the commission, the Federal courts and into Congress. By the commission's original action the lake cargo rates from the Ohio-Pennsylvania territory were cut 20 cents per ton and Southern railroads, serving Kentucky, Tennessee and West Virginia mines which compete for the lake cargo traffic, cut rates from that territory an equal amount.

The Baltimore and Ohio will not receive the full 20 cents a ton reduction in lake cargo rates, as the Pennsylvania, New York Central and other systems. The Baltimore and Ohio failed to incorporate in its application the full amount of the reductions which the other roads allowed and the commission refused to permit the line to waive the usual 30-day requirement for putting new rates into effect when it tried to revise their schedules to correspond with those of the other roads. The reduction, however, by the Baltimore and Ohio is expected to be placed into effect later.

Indiana Operators Disband

At a meeting, held in Terre Haute, June 5, the Indiana Bituminous Coal Operators' Association was disbanded by vote of the membership. W. H. Hamilton, the last president, was designated as trustee and directed to take charge of the funds until July 1. At that time, after all obligations are discharged, the funds remaining will be divided among the contributors who were members in good standing as of date of disbandonment. At a meeting of the executive board which preceded the final meeting, the resignation of Phil H. Penna, who was secretary of the organization for several years, was accepted.

New Association Formed

Coal operators from all producing districts in the state at a meeting June 20, completed the organization of the Indiana Coal Trade Association.

The new organization, whose membership will include both shaft mine and strip mine operators, in addition to continuing the work now being conducted by the Traffic Department of the disbanded Indiana Bituminous Coal Operators' Association, will engage in various other activities which affect the marketing of Indiana coal.

Robert J. Smith, president, Princeton Mining Co., and R. C. Woody, vice president of the Electric Shovel Coal Corporation, were elected chairman and vice chairman, respectively, of the executive committee. Jonas Waffle, who has been connected with the industry for the past 10 years, was elected executive secretary and will manage the affairs of the association.

Research Committee Appointed

J. P. Williams, Jr., vice president of the Melcroft Coal Co., and chairman of the research committee of the National Coal Association, has appointed a committee "to formulate, if possible, some plan or plans along research lines covering subjects in which there are common interests." The committee was appointed in accordance with a decision reached at the research conference held in New York on February 9 last, under the auspices of the National Coal Association and which was attended by 25 representatives of 18 organizations interested in bituminous coal research. The committee will make a report to a meeting to be called later.

The members of the committee are: Ezra Van Horn, National Coal Association (chairman); W. C. Beckjord, American Gas Association; A. C. Fieldner, U. S. Bureau of Mines; F. C. Houghten, American Society of Heating & Ventilating Engineers; Frank W. Miller, National Coal Association; E. P. Ricketts, National Electric Light Association; H. J. Rose, American Institute of Mining & Metallurgical Engineers; and F. R. Wadleigh, American Society of Mechanical Engineers.

The Colorado Fuel and Iron Company has adopted group life insurance for more than 11,000 employes in properties stretching from Wyoming to the Mexican border involving $20,000,000. The Equitable Life Assurance Society will underwrite it.

Fluorspar Report Ready

The report on fluorspar, which has been in preparation for some time by the iron and steel division of the Tariff Commission, is now in the hands of the advisory board of the commission for its consideration before going to the commission itself for final action.

The manganese ore report is nearing completion by the iron and steel division for submission to the board. Plans are also being developed for the investigation of tungsten, which was requested by a Senate resolution. Import analysis on this survey is now under way.

Reading Coal Stock Sale is Approved

The bid of $30 a share by the National City Co., of New York, at public auction June 18, for the 6,958 unconverted shares of the capital stock of the new Philadelphia and Reading Coal & Iron Corporation, has been accepted by the United States District Court at Philadelphia.

The sale, which is one of the concluding features of the mandate issued several years ago for the dissolution of the Reading associated companies, was the result of the failure of the holders of the certificates of interest to convert them into shares before April 1.

The National City's bid, which was the only offer made for the stock when it was put up at auction under direction of the court, calls for the payment of a total of $208,740, which will be distributed among the holders of the unconverted certificates in proportion to their holdings.

Central Pennsylvania Coal Operators' Association to Meet July 6

The Central Pennsylvania Coal Producers' Association, embracing within its membership the leading coal-producing companies in the Central Pennsylvania District, will hold a semiannual meeting at Ebensburg, Pa., July 6, 1928, during the Cambria County Industrial Exposition. The meeting of the operators will be held in the pavilion on the exhibition grounds. Mines owned and operated by the association members are located in the counties of Armstrong, Bedford, Blair, Bradford, Cambria, Cameron, Center, Clarion, Clearfield, Clinton, Elk, Fulton, Huntingdon, Indiana, Jefferson, Lycoming, Somerset, Sullivan, Tioga, and Westmoreland. Membership of the association is about 200 companies. The officers are as follows: B. M. Clark, president; G. Webb Shillingford, vice president; W. A. Jones, statistician; Charles O'Neil, secretary-treasurer.

The members of the Board of Directors are as follows: Rembrandt Peale, Chas. A. Owens, J. W. Searles, S. T. Brown, B. M. Clark, Jas. H. Allport, R. H. Sommerville, M. J. L. Bracken, H. J. Meehan, S. J. Wills, F. B. Kerr, G. Webb Shillingford, J. R. Cassley, C. B. Maxwell, Harry Boulton, F. D. Lambert, D. T. Price and Edgar W. Tait.

The tentative program includes the meeting at the Exposition Fair grounds at 9 a. m. During the morning the representatives of the coal companies, including owners, managers, superintendents, foremen, etc., will visit the exhibits.

At noon a buffet lunch will be served to the representatives of the coal companies. In the afternoon the annual golf tournament between the eastern and western sections of the district will be played.

Two golf courses have been secured for the match. For that day Mr. Charles M. Schwab has kindly invited the operators to use his private course at Loretto, and the Summit Country Club of Cresson has agreed to give their course. One half of the teams will play at Loretto and the other half at Cresson. Mr. Schwab will play on one of the teams.

In the evening at 7 o'clock dinner will be served at the pavilion for all representatives of the association and their guests. Mr. Schwab, who is president of the Industrial Exposition, and among other things one of the largest coal operators in the United States, has been invited to address the meeting.

A number of prominent operators of western Pennsylvania have also been invited by the association to attend the meeting.

Speakers Lining Up for Second Bituminous Coal Conference at Carnegie

Between 60 and 70 scientists and fuel technologists in 11 different countries, it is announced, have tentatively accepted invitations to speak at the Second International Conference on Bituminous Coal, which will be held at the Carnegie Institute of Technology, in Pittsburgh, during the week of November 19, 1928. The list includes about 40 Europeans whom Dr. Thomas S. Baker, president of the Carnegie Institute of Technology, personally invited while making his recent two months' visit in Europe in the interests of the coal conference.

The purpose of the coming congress, the announcement points out, is similar to the one held in 1926 by the Carnegie Institute of Technology: To present the results of recent studies of coal that have to do with improved methods of utilization and combustion. The program will include the discussion of low-temperature distillation, high-temperature distillation, coal-tar products, power, smokeless fuel, complete gasification of coal, hydrogenation, pulverized fuel and its new applications, fixation of nitrogen, coal beneficiation, etc.

Upon his return from Europe in April, President Baker expressed the opinion that the second conference will be much larger in scope and importance than the first, and that the number of delegates from foreign countries will be considerably in excess of that at the 1926 meeting, when 13 different nations were represented.

Among the distinguished scientists in Europe who have either definitely or tentatively accepted invitations to speak at the second congress are the Right Hon. Sir Alfred Mond, Harald Nielsen, Dr. Cecil H. Lander, and Dr. R. Lessing, of England. Donat Agache, president of the executive board of the Kuhlmann plants; Andre Kling, director of the municipal laboratories of Paris, and Henri Lafond, International Company for the Manufacture of Gasoline and Oils, France. Dr. Friedrich Bergius, inventor of the Bergius process for the production of oil from coal; Dr. Franz Fischer, director of the Kaiser Wilhelm Institute for Coal Research; Prof. Fritz Hoffman, inventor of a process for manufacturing snythetic rubber from coal; Dr. Carl Krauch, director of the I. G. Dye Trust; and Rudolph Rawlikowski, of the Cosmos Machine Construction Institute, Germany.

Plan Course for Miners in West Virginia

Plans for giving advanced courses for the training of mine foremen were considered recently at a conference between officials of the West Virginia Department of Education, Department of Mines and officials of various coal companies of the New River Coal Operators' Association.

Those attending the conference included R. H. Morris, Ansted, general manager of the Gauley Mountain Coal Co.; S. C. Higgins, secretary of the New Rivel Coal Operators' Association; J. P. White, general superintendent of the Raleigh Coal & Coke Co., at Raleigh; R. M. Lambie, chief of the State Department of Mines; J. F. Marsh, secretary of the State Board of Education and Director of Vocational Education; T. P. Hill, Assistant State Superintendent of Schools; Gilbert Smith, of Fayetteville, general manager of the Fire Creek Coal & Coke Co., Dunedin Coal Co., and Terry Coal Co., and G. E. Hubbs, assistant in industrial education of the State Department of Education.

The State Department of Mines is already giving some instruction in the training of mine foremen, but the proposed plans for advanced instruction to be given through the cooperation of the State Board of Education, the Federal Bureau of Vocational Education and the School of Mines of West Virginia University.

Schwab Sees No Good in Coal Investigation

Charles M. Schwab, chairman of the board of the Bethlehem Steel Corporation, stated early in June he "did not believe the Senate committee investigating the coal strike has done any good—yet.

"What the Senate committee did was not constructive," the steel man continued. "It does no good to stir ill feeling, and that's about all it did. I'm deeply interested, of course, in the strike, and want to see the parties get together, but I don't feel they went about it right. I was there, you know, at Washington."

Brookside-Pratt Mining Company Plans Improvements

The Brookside-Pratt Mining Company, Birmingham, will make a number of improvements at its New River mine, in Marion County, Ala., in order to provide facilities for increasing production as needed. An additional concentrator will be installed in the preparation plant. Haulage equipment will be increased by the addition of 75 tram cars, and provision for increasing coal cutting will be made by the addition of several new mining machines to the present fleet. Twenty-five four-room houses will be constructed to take care of new employes.

Seek Foreclosure of Mortgages on W. Va. Coal & Coke Properties

A bill of complaint seeking foreclosure of $10,000,000 in mortgages on properties of the West Virginia Coal and Coke Co., in nine counties of West Virginia, and the sale of the properties was filed in Federal District Court at Charleston, June 12, by attorney for Walter F. Kearns and the First National Bank of New York as trustees for holders of the mortgages.

A receivership was named by Federal Judge George W. McClintic several months ago on petition of the Goodman Manufacturing Co., of Chicago, a creditor.

Anthracite Exposition Arousing Interest

The Anthracite Boosters' Association, with headquarters in Philadelphia, reports that residents of the anthracite region are taking keen interest in preparations for the educational exposition to be held at Willow Grove Park, August 4 to 11, under auspices of the association.

Exhibitors are preparing to demonstrate to the public new types of labor-saving devices taking away past drudgery in connection with the use of anthracite.

Letters commending the plan of the exposition have been received by the association from Mayor Hart, of Wilkes-Barre; Mayor Gillespie, of Pittston, and many others.

The association points out that the anthracite industry pays in wages to miners more than $325,000,000 a year; the coal-carrying companies are paid about $150,000,000 a year; supplies cost $75,000,000 a year, and taxes $20,000,000 a year.

World's Largest Shovel at Northern Illinois Coal Corp. Operation

On May 22, the Northern Illinois Coal Corporation held a formal opening of a new coal stripping operation near Wilmington, Ill. Approximately 1,500 invited guests made the trip, either on the special train which ran from Chicago to the mine or by automobile direct to the mine. These guests included coal buyers and users, underground and strip mine operators, and executives and persons interested, in general, in large excavating projects.

The operation is unique in that it is an entirely new project, laid out in a most scientific manner and completely equipped with the most modern and efficient machinery obtainable. Three electric excavators are used, which include a type 360 electric dragline, a type 5480 electric stripping shovel and a type

37 coal loading shovel, all built by The Marion Steam Shovel Co.

The type 5480, shown above, is the largest shovel ever built. Statistics and figures hardly give a true conception of the shovel and what it does, but some idea of its immensity may be obtained from the following:

The shovel carries a 12-cu. yd. dipper on a 90-ft. boom and a 60-ft. dipper handle. It is mounted on crawling traction tracks and is operated electrically from the power lines of the public utility company serving that territory. A 750-hp. motor drives the motor-generator set for furnishing power to the various motions and the working weight with ballast is approximately 850 tons.

The shovel operates three 8-hour shifts each day, Sundays excepted, and it has, since being placed in operation, handled 15,481 cu. yds. in a 24-hour period. This far exceeds the daily production of any machine heretofore used for this class of work. It is expected that in a calendar year it will handle from two to three million cubic yards of material.

Prior to the erection of the above shovel, the largest coal stripping unit had been the Marion 350 which carried an 8 cu. yd. dipper, a 90-ft. boom and a 58-ft. dipper handle. This machine operated in overburden up to 40 ft. in thickness where the vein of coal averaged 5 ft. in depth. However, there is much strippable coal having an overburden not exceeding 40 ft. in thickness, but where the coal averages only about 3½ ft. in thickness. It was to operate under the latter condition that the 5480 was developed although as in the case of The Northern Illinois Coal Corporation, its use may be extended to a thicker coal vein with a consequent decrease in production costs.

Cause of Mather Blast is Unknown

A coroner's jury which recently held an inquest into the explosion at the Mather mine of the Mather Collieries Co., in which 195 miners lost their lives, have rendered a verdict that the "explosion was caused by a combination of gas and coal dust igniting in some unknown manner."

Two juries, one to make identifications and the other to inquire into the blast, were empaneled by the coroner.

The explosion occurred on May 19.

Mine Sale Opposed

Holders of securities in the Belmont Collieries Company are planning an appeal to the Seventh District Court of Appeals, at St. Clairsville, Ohio, in an effort to halt the sale of the company's drift and strip mines at Uniontown for $121,000 to the Warner Collieries Company, of Cleveland, approved in Belmont County Court. The firm has been in a receiver's hands for six years, and this is the largest offer ever made for the mines and coal fields once worth $2,000,000.

The Consolidated Coal Co., of Butler, Pa., has acquired the properties of the Consolidated Coal & Coke Co. in Indiana County and is asking stockholders to authorize an increase of the company's outstanding obligations from $5,300,000 to $6,000,000. The company also has purchased a half interest in certain coal lands in Allegheny County from the T. W. Phillips Gas and Oil Co., of Butler.

Susquehanna Collieries Company Activities in Forestry

During the year 1926 the Shamokin, Pa., Division of Susquehanna Collieries Co. mapped out a tentative program of reforestation to be undertaken on a small scale. Accordingly, a portion of land 2,400 ft. square, containing about 130 acres, was selected as the ideal site to start this program. The outside border of this proposed site was protected by cutting a 50-ft. fire lane around the entire area. The interior land was then subdivided into 500-ft. square and these were protected by fire lanes on all sides.

The land selected was considered ideally located, being far removed from any habitation and well off the beaten roads and trails, which tends to make the fire hazards less from careless persons traversing the forest lands. The soil is rich and lies in a broad flat valley, and is ideally suited for the project, as it contains a great amount of moisture derived from the surrounding hillsides. The growth on this land was sparse and comprised for the greater part of low scrub oak and some pine. The scrub oak was thinned out in order to make conditions better for the seedlings.

During the year 1927 there was secured from the Department of Forests and Waters, Harrisburg, Pa., their first shipment of seedlings, consisting of 3-year-old red pine, Scotch pine, white pine and Norway spruce in equal quantities to make up 10,000 seedlings. Immediately upon receipt of these trees a force of men especially instructed were delegated to plant them according to methods prescribed by the Department of Forests. These trees were spaced about 6 ft. apart, making 6-ft. squares, and allowed to grow.

The winter of 1927-1928 having been mild and open, it was feared that a great number of trees would be frozen on account of the swampy condition of a portion of the land on which some were planted, but, upon examination of the 1927 seedlings this spring, it was found that those planted in the swampy section had outgrown trees planted on the higher ground.

In April of this year they received their second consignment of 10,000 trees divided as follows: 2,500 red pine, 2,500 Scotch pine, 2,500 white pine, 2,500 Norway spruce. They were planted immediately in their allotted area under the same plan and system.

It is the intention in the Shamokin Division of Susquehanna Collieries Company to follow this program for the next several years in order to help carry on the program of the Department of Forests and Waters of the State of Pennsylvania. They have appointed the outside foreman at each of their operations a special fire warden and have delegated a certain number of men to aid in fighting fires on their property in order to protect as far as possible the second growth timber which covers their lands in this division.

Potash Development in Texas

The American Potash Co. of Texas has been organized to conduct potash development in the territory south of Odessa, Tex. Plans are being made for the sinking of a well-equipped shaft 10 miles from Odessa, where the company already has completed several exploratory tests.

Liquification of Coal by Germans Progressing

At the recent general meeting of the German Dye Trust, President Bosch announced that the firm was making good progress in the liquification of coal process, increasing its output and finding a ready market for its benzine. With completion of an extension to the Leuna Works, production of benzine is expected to reach 100,000 tons in 1928 and double that amount in 1929.

Experiments in the extraction of lubricants, paraffin and other products from coal is very promising, the president announced. He added that one of the Standard Oil companies, with the assistance of the Dye Trust, was erecting an experimental plant in the United States, and that a start would be made for the extraction of products from coal this year.

Mexican Copper-Mining Co. Has Notable Safety Record

The measures taken by a copper mining company at Pilares, Sonora, Mexico, for the protection of its miners from accidents have so impressed the Bureau of Mines that a report outlining the accident prevention policies of the company has been issued. Safety rules are established at this mine, and in general are enforced, according to E. D. Gardner, the author of the report, and workmen and bosses with good safety records receive extra consideration, while violators of safety rules are disciplined. The company gives a fiesta, or holiday, with suitable entertainment, to the workmen whenever a 30-day period is completed underground without a lost-time accident.

Mining operations at this mine are planned to afford a maximum of safety to the workers. Safeguards are installed where needed, the cause of each individual accident is studied, mining practices are improved where they are found deficient, and rules are established to prevent, in so far as feasible, recurrence of any particular type of accident.

In 1925 three fatalities and 275 lost-time accidents occurred at this mine. During that year a concerted effort was started to reduce the number of accidents; in 1926 there were four fatalities and 78 lost-time accidents. Although the fatalities increased by one, the total number of accidents was less than a third of the number for 1925. A total of 428,905 shifts was worked in 1926.

Further details of accident-prevention measures taken at this mine are given in Information Circular 6059, which may be obtained from the United States Bureau of Mines, Washington, D. C.

Further Potash Discoveries Made

Further discoveries of substantial bodies of potash salts in Texas have been announced by the Interior Department. It has tested the cores brought up from four wells recently drilled. The most promising of these is in Ector County, where two beds with a combined thickness of 6 ft. 7 in. were encountered a little more than 1,900 ft. down.

The borings have been made under the potash act, which provides for joint explorations by the Geological Survey, representing the Department of the Interior, and the Bureau of Mines, representing the Department of Commerce. These discoveries mark the latest episode in a chain of events that extends back many years and that may in the end result in establishing America's independence of Germany in the matter of potash fertilizer.

Prices of imported potash are now moderate, but the foreign monopoly has become reestablished and continues to be a potential threat against the security of American agriculture and the American national defense. Hence the necessity still exists for information regarding possible sources of potash in this country that may be worked more cheaply than those which were brought into costly production under the pressure of war-time conditions.

The most promising sources of potash brought to light by Federal investigations are the potash salts associated with the great Permian salt deposits of Texas and New Mexico, which have been known and studied in a general way by the Geological Survey for some years. Since, however, these lie at depths ranging from 500 to 2,500 ft. below the surface, detailed and accurate information regarding their nature and quantity could not be obtained without expensive core drilling. It is only since June, 1926, when Congress in the so-called potash act authorized a five-year program of potash explorations by drilling, that it has been possible to get accurate data from the Texas-New Mexico field. The annual appropriation under this act is $100,000, and the second year of exploration on this basis is drawing to a close. Seven holes have been drilled and reported on, and an eighth hole already started will be completed before the end of the fiscal year.

The action of Congress in making this appropriation has already been rewarded. Each of the holes thus far drilled has encountered some potash salts, but in three of the holes, one in New Mexico and two in Texas, substantial bodies of potash rich enough to have commercial promise have been discovered.

WITH THE MANUFACTURERS

New Paint Spray Gun

The new Milburn paint spray gun, manufactured by the Alexander Milburn Co., Baltimore, Md., has two important additions. These features are, first, a dialed head which gives numerous different spray adjustments from a circular spray to a fan of a wider field than has heretofore been possible with spray guns. The dialing permits the operator to obtain any desired spray instantly without first making tests. Secondly, a series of indicator numerals on the paint valve plunger. A pointer is operated as the operator turns the adjustment button. Just as the dial in the head produces the exact spray wanted, so the indicator numerals on the paint valve plunger provide the exact volume desired without the necessity of losing time by testing. The new gun is known as the Type EF.

New R. & S. Tipple

The Panther Creek Mines, Inc., Springfield, Ill., have recently contracted with the Roberts & Schaefer Co. for complete steel tipple and concrete retail bins to be installed at their retail mine in Springfield, Ill.

The following installations of Menzies Hydro Separators for cleaning coal are indicative of better conditons and more efficient methods in the coal industry: Bradshaw Coal Co., Dan, W. Va.; Gulf Smokeless Coal Co., Tams, W. Va.; Gulf Smokeless Coal Co., Hot Coal, W. Va.; Collier-Dunlap Coal Co., Hartman, Ark.; Marion County Coal Co., Centralia, Ill.; Koppers Coal Co., Maitland, W. Va.

With the announcement of the completion of their new plant and the increase of their facilities some 200 percent, the company formerly known as the Naylor Spiral Pipe Co. also announces the change in name to the Naylor Pipe Co.

The new product of this organization, "Spiralweld Toncan Iron Pipe," no longer being comparable to light weight, sheet metal pipe, but putting it rather in the category of standard weight pipe, has necessitated the increased facilities as well as the change in company name.

There will be no change in management, all officers and executives carrying on in their present positions.

Far-Reaching Lightning Studies Initiated by Westinghouse

During the next six months, according to W. S. Rugg, vice president of the Westinghouse Electric & Manufacturing Co., electrical engineers of his company, armed with every scientific device obtainable will record each bolt and quirk of every thunderstorm that plays around the crest of Chilhowee Mountain, in Tennessee.

Since the site where the apparatus is to be located, Chota, Tenn., has an average of 20 thunderstorms each month during the summer, the engineers will have an active time, states Mr. Rugg.

The instruments used by the young engineers, who will spend the next six months, or six years if necessary, on the job, will consist of Norinder oscillographs, osisos, klydonographs, cameras and other apparatus, not only to record but also to diagnose the effect of each lightning flash. This apparatus, to be installed on the power lines of the Aluminum Co. of America, will cover a 5-mile stretch of wild terrain.

New Control for Automatic Arc Welding Eliminates Arc Crater

The General Electric Co. announces an improvement in the control equipment used with its automatic arc welding heads, by means of which the feed of electrode wire is stopped a short time before shutting off the welding current at the end of the weld. This serves two purposes: First, it clears the electrode from the weld and, second, it fills in the crater which is inevitably left at the end of the weld when the arc is cut off short.

According to the manufacturer, it is always desirable to have the electrode clear of the weld when removing the work from the clamping fixture, to prevent the end of the wire from dragging. This is of particular importance with large sizes of wire. Many users of arc welding also want to eliminate the undesirable crater, as they find its presence is objectionable, especially on circular welds of small diameters, where one end of the weld is lapped over on the other end.

The General Electric control panel for its automatic arc welding heads is controlled by a "START—STOP" push-button station.

First Oil Electric Switcher Locomotive Shipped

The first light- weight oil - electric switcher locomotive to be built in America has been shipped from the East Pittsburgh works of the Westinghouse Electric and Manufacturing Co. to New York, where it will be put in service on the Long Island Railroad. This locomotive, which is capable of producing 600 hp., weighs only 85 tons and burns the very cheapest grades of fuel oil.

New Potential Transformer Fuse and Wire Wound Resistor

The Westinghouse Electric & Manufacturing Co. announces a Type H combination potential transformer fuse and wire-wound resistor for 2,500 to 25,000 volt service. It is intended for indoor application, and can be mounted on any flat surface or upon 1¼-in. pipe.

The resistors are placed in series with the fuses and effectively limit the current in case of short circuit. This permits the use of potential transformer fuses on any circuit regardless of its short-circuit amperes, provided the voltage rating of the system is not more than that of the fuses and resistors.

The May issue of "Mine and Quarry," published by the Sullivan Machinery Co., Chicago, Ill., contains two articles which should prove interesting to mining men. They are: The "Speed Drift" at the Eureka Mine, by John M. Price, superintendent of the Castile Mining Co., Ramsay, Mich., and "Scraper Loading in Anthracite," by E. W. Noyes, of Scranton, Pa.

John A. Garcia Receives Degree

John A. Garcia, consulting engineer of Chicago, was granted the degree of Doctor of Engineering (honoris causa) at the commencement of the School of Mines and Metallurgy at Rolla, Mo., on May 24.

Following extensive experience in the Oklahoma and Illinois coal fields, Dr. Garcia entered consulting work in Chicago, forming a partnership with Andrews Allen, the organization specializing in the construction, development, operation and examination and reports on bituminous coal mines, and later branching out into bridge work and industrial plant construction.

Lubrication of Wire Rope

According to the American Cable Co., practically all the cores of good brands of wire rope are thoroughly impregnated with a commercial, chemically-neutral rope oil. They further say: "While the core retains a liberal supply of this lubricant which gradually oozes out as the rope is used, still, frequent application of a good lubricant during service is necessary to prevent the core from becoming dry. A dry core will both wear and crush quicker than an oil-impregnated core. Furthermore it will absorb moisture with the result that the core will deteriorate rapidly and the inner wires will corrode with shortened rope service as the result.

"The smaller the sheaves or the heavier the tension on the rope, the more often should the rope be lubricated. A good lubricant retards corrosion of the wires and deterioration of the core, reduces internal friction which is the cause of wires breaking from bending stresses, and decreases external wear. The lubricant should be thin enough to penetrate the strands and the core but not so thin as to run off the rope nor so thick that it merely covers the rope.

"Therefore, a thicker, semi-plastic compound applied hot and in a thinned condition, is the best wherever possible. It will penetrate while hot, then cool to a plastic filler, excluding the entrance of water, both preserving and lubricating the inner wires and cores.

"To properly lubricate with a heated lubricant, it is necessary to have the rope run slowly through a tank of heated oil. This is the best possible method to allow penetration. Where this is not possible, an application of a thinner and unheated lubricant will give better practical results.

"It is always well to lubricate the rope just after installation and before running in service, particularly when such ropes have been kept in storage for any length of time."

Eight-Inch Stroke Angle Compressors

Sullivan Machinery Co. has issued a new bulletin, 83-K, in which their new small-size Angle Compound Compressors are described.

According to their statement "these compressors are built on the same principle and design as our larger Angle Compound machines, and extend to machines as small as 300 cu. ft. displacement capacity the advantages of the Angle Compound idea, including compactness, exact balance of reciprocating parts, freedom from vibration and the features of low-power consumption."

Copies of the bulletin can be obtained from the company at 122 South Michigan Avenue, Chicago.

The Reed-Prentice Corporation of Worcester, Mass., who brought out the Wolf Portable Timber Sawing Machine last year, have announced this tool in a new type, using an Ingersoll-Rand type A air motor.

The operation of the air-driven Wolf Saw compares in every way with the previously announced electrically-driven machine, and with the exception of the motor, throttle, motor housing, and drive gears, it is identical in design and construction.

Large savings as high as $40 per day are said to have been made with this machine by contractors, railroads, mining companies, timber-treating plants, lumber yards, public utilities, etc., and it has already been used to a depth of 24 feet under water, for cutting piling.

Ingersoll-Rand Co., New York, announces publication of a new 44-page bulletin on ER and FR Compressors and vacuum pumps. These are the small and intermediate size machines.

The compressors are furnished for handling either air or gas. They are of straight-line type and are built as single-stage, two-stage, or three-stage units. The single-stage units are made in sizes having piston displacements of from 28 to 1,084 cubic feet per minute at discharge pressures of 15 to 160 pounds to the square inch. The multi-stage units provide for discharge pressures up to 1,750 pounds.

ER compressors and vacuum pumps are arranged for driving by short or long belt or by direct-connected synchronous motor. FR units are steam driven.

Single-stage air compressors of this type are suitable for a wide variety of applications. They are in use throughout the world for furnishing air for mines, quarries, industrial plants, garages, ice plants, elevator service, etc.

The vacuum pumps are single-stage machines that differ from the compressors only in the vacuum cylinder. With intake closed, they will pull 28 to 29 inches of vacuum referred to a 30-inch mercury column.

The bulletin, No. 3150, is available at any Ingersoll-Rand office.

Electrical Precipitation

The General Electric Co., Schenectady, N. Y., has issued a bulletin (No. 916) entitled "Electrical Apparatus for use with the Cottrell Precipitation Process." The Cottrell method of precipitating dust and other particles from fumes and smoke by the application of high-voltage, unidirectional current has been in commercial use for some time, and the bulletin mentioned carries a detailed description with a bibliography on the subject.

Link-Belt Co. Issues 1,088-Page Catalog and Engineering Data Book

If the amount of usable information put into a general catalog is any criterion of its worth, then the Link-Belt General Catalog 500, published by Link-Belt Co., of Chicago, Indianapolis and Philadelphia, is a good example of what an informative general catalog should be.

It consists of 1,088 pages, and not only covers in engineering data and list prices the complete chain, sprocket, power transmission, elevating and conveying and engineering divisions of that company's business but contains considerable data for which the engineer has use.

In developing this book it was evidently their purpose not only to make its contents of engineering information so ample that engineers might design plants of a standard character without their aid, but also to supply price lists so complete as to enable the experienced buyer to determine net prices of his purchases.

The book is admirably arranged to serve these purposes. In addition to being an unusual engineering catalog, it is a textbook of the conveying, elevating and chain transmission art.

New Sullivan Compressor Catalog

Sullivan Angle Compound compressors of capacities from 300 to 5,100 cu. ft. of free air per minute are described in a new bulletin, No. 83-J, which may be obtained upon request to the Sullivan Machinery Co., 122 South Michigan Avenue, Chicago.

In additon to the general description of the Angle Compound machine, the bulletin, which is 6 x 9 in. in size, 32 pages, is featured by numerous illustrations of installations of these machines. Views are shown of the machine operated by direct-connected Diesel engine, by short center belt drive from electric motor, by direct-connected motor drive, in both single and twin units, including some units operated by magnetic clutches, and others equipped with stop and start control. The "Multi-step" system of load control, a distinctive feature of these machines, is described in this bulletin.

National Malleable & Steel Castings Co., of Cleveland, have recently released Circular No. 87, covering Hitchings, Couplers and Wheels for Mine and Industrial Cars.

The Fusion Welding Corporation, 103d Street and Torrence Avenue, Chicago, have recently issued a bulletin descriptive of their Fuzon flexible arc welders. Copies may be had upon request.

"Hughes Drilling Valves and Fittings" are described in detail in a 24-page bulletin just issued by the Hughes Tool Company, main office at Houston, Tex.

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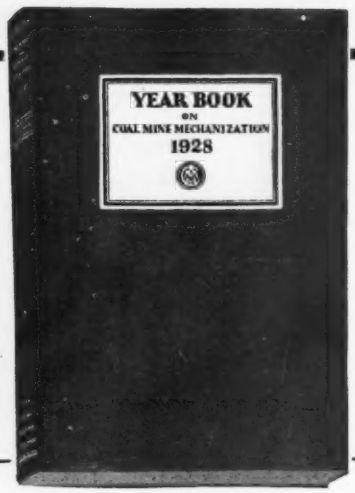

"it is gotten up in wonderful shape and I believe that it tells the mechanization story better than anything else along that line."

This is characteristic of the comment that is already coming in on the YEARBOOK ON COAL MINE MECHANIZATION. The book describes LOADERS, SCRAPERS AND CONVEYORS operating under practically every coal mining condition; the physical conditions encountered, mining system used, the mechanical operation, timbering and roof action, operating crew, equipment and preparation.

It also contains technical descriptions and illustrations of every type of loader, conveyor and scraper manufactured. It outlines progress of mechanization in each of the coal mining states and furnishes a bibliography of coal mine mechanization as published during the years 1920 to 1927.

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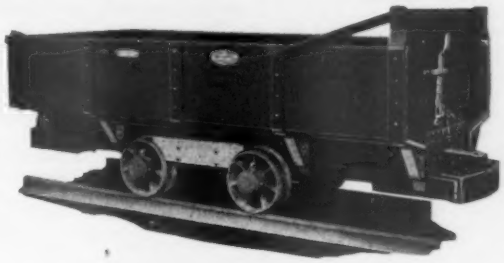

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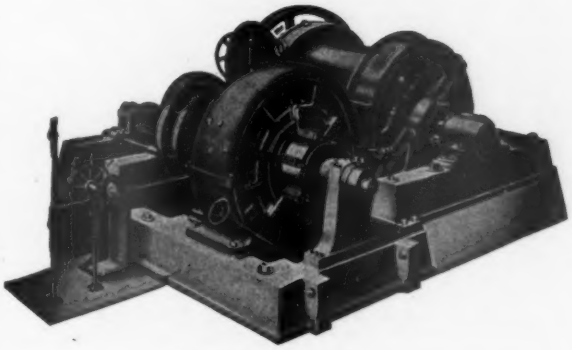

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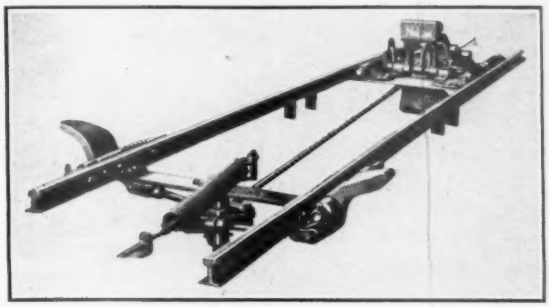

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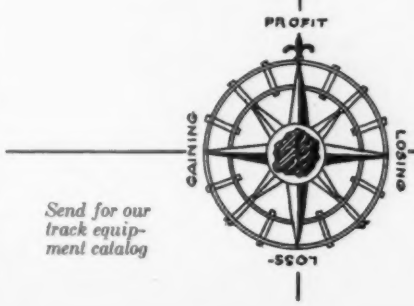

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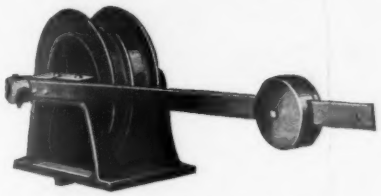

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FEEDERS (Crossover, Kickback, Rotary and Dump)
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Mining Safety Device Co., Bowerston, Ohio.
Phillips Mine & Mill Supply Co., Pittsburgh, Pa.
Roberts & Schaefer Co., Chicago, Ill.

FEEDERS (Gravity)
American Coal Cleaning Corpn., Welch, W. Va.

FEEDERS (Hand Operated)
Mining Safety Device Co., Bowerston, Ohio.
Roberts & Schaefer Co., Chicago, Ill.

FEEDERS, ORE
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

FEEDERS (Reciprocating)
American Coal Cleaning Corpn., Welch, W. Va.

FEEDERS (Semi-automatic)
Mining Safety Device Co., Bowerston, Ohio.
Phillips Mine & Mill Supply Co., Pittsburgh, Pa.

FENCE POSTS
Sweet's Steel Co., Williamsport, Pa.

FIBRE GREASES
Standard Oil Co. (Ind.), Chicago, Ill.

FILTERS (Dust)
American Coal Cleaning Corpn., Welch, W. Va.

FIRE TRUCK, MINE
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

FIRE AND WEATHER-PROOF WIRE
John A. Roebling's Sons Co., Trenton, N. J.

FIRST-AID SUPPLIES
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

FLASHLIGHTS AND BATTERIES (Mine Safety)
National Carbon Co., Inc., 30 East 42d Street, New York City.

FLOORING, OPEN STEEL
Hendrick Mfg. Co., Carbondale, Pa.

FLOTATION MACHINES
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

FLOTATION OILS
Hercules Powder Co., 934 King St., Wilmington, Del.

FLOW METERS
General Electric Co., Schenectady, N. Y.

FLUX, WELDING
Oxweld Acetylene Co., 30 E. 42d St., New York City.

FORGINGS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

FROGS
Central Frog & Switch Co., Cincinnati, Ohio.
Sweet's Steel Co., Williamsport, Pa.

FROGS AND SWITCHES
Central Frog & Switch Co., Cincinnati, Ohio.
West Virginia Rail Co., Huntington, W. Va.

FURNACE OIL
Standard Oil Co. (Ind.), Chicago, Ill.

FURNACES, Oil (for drill steel)
Ingersoll-Rand Co., 11 Broadway, New York City.

FURNACES, ROASTING
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

GAS ANALYSIS APPARATUS
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

GAS (Cutting, Welding)
Prest-O-Lite Co., Inc., 30 E. 42d St., New York City.

GAS (Nitrogen, Oxygen)
Linde Air Products Co., 30 E. 42d St., New York City.

GASOLINE
Standard Oil Co. (Ind.), Chicago, Ill.

GAS ENGINE OILS
Standard Oil Co. (Ind.), Chicago, Ill.

GAS MASKS
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

GAUGES, WELDING & CUTTING
Central Frog & Switch Co., Cincinnati, Ohio.

GAUGE RODS
Central Frog & Switch Co., Cincinnati, Ohio.

GAUGES, WELDING & CUTTING
Oxweld Acetylene Co., 30 E. 42d St., New York City.

GEAR COMPOUNDS
Standard Oil Co. (Ind.), Chicago, Ill.

GEARS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

GEARS, BEVEL
Fawcus Machine Co., Pittsburgh, Pa.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

GEARS (Fabroil & Textolite)
General Electric Co., Schenectady, N. Y.

GEARS, HERRINGBONE
Fawcus Machine Co., Pittsburgh, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

GEARS, Machine Cut
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

GEARS, Moulded Tooth
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

GEARS, Silent Chain
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

GEARS, SPUR
Fawcus Machine Co., Pittsburgh, Pa.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

GEARS, WORM
Fawcus Machine Co., Pittsburgh, Pa.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

GEARS, WORM WHEELS
Fawcus Machine Co., Pittsburgh, Pa.

GELATIN DYNAMITES
Hercules Powder Co., Wilmington, Del.

GENERATORS AND GENERATING SETS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

GENERATORS, ACETYLENE
Oxweld Acetylene Co., 30 E. 42d St., New York City.

GLOVES, ASBESTOS
Oxweld Acetylene Co., 30 E. 42d St., New York City.

GOGGLES, MINERS' WIRE SCREEN, NOD AND SHAKE WELLSWORTH
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

GOGGLES, WELDING
Oxweld Acetylene Co., 30 E. 42d St., New York City.

GRAPHITE GREASES
Standard Oil Co. (Ind.), Chicago, Ill.

GRATING, AREA, SIDE WALK
Hendrick Mfg. Co., Carbondale, Pa.

GREASE
Keystone Lubricating Co., Philadelphia, Pa.
Standard Oil Co. (Ind.), Chicago, Ill.

GRIFFIN MILL
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

GRINDERS, Portable Pneumatic
Ingersoll-Rand Co., 11 Broadway, New York City.

GUARD RAIL CLAMPS
Central Frog & Switch Co., Cincinnati, Ohio.

GUY ROPES, GALVANIZED
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

HAMMERS, Calking, Chipping & Riveting
Ingersoll-Rand Co., 11 Broadway, New York City.

HANGERS
S K F Industries, 40 E. 34th St., New York City.

HANGERS (Insulated Trolley)
Ohio Brass Co., Mansfield, Ohio.

HANGERS, Ball Bearing
S K F Industries, New York City.

HANGERS, SHAFT, DROP
S K F Industries, New York City.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

HANGERS, SHAFT, POST
S K F Industries, New York City.

HANGERS, SHAFT, SELF-OILING
S K F Industries, New York City.

HARD-BOILED CAPS AND HATS
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

HAULAGE ROPE
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

HEADLIGHTS, ARC AND INCANDESCENT
General Electric Co., Schenectady, N. Y.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Ohio Brass Co., Columbus, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

HEATER CORD
John A. Roebling's Sons Co., Trenton, N. J.

HERRINGBONE GEAR DRIVES
Fawcus Machine Co., Pittsburgh, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

HIGH EXPLOSIVES
Hercules Powder Co., Wilmington, Del.

HIGH-PRESSURE OXYGEN PUMP
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

H-H INHALATORS
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

HOIST DRIVES
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

HOISTING ROPES
American Steel & Wire Co., Chicago, Ill., and New York.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
John A. Roebling's Sons Co., Trenton, N. J.

HOISTS
American Steel & Wire Co., Chicago, Ill., and New York.
Ingersoll-Rand Co., 11 Broadway, New York City.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

HOISTS, AIR
Ingersoll-Rand Co., 11 Broadway, New York City.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

HOISTS, ELECTRIC
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Diamond Machine Co., Monongahela, Pa.
S. Flory Mfg. Co., Bangor, Pa.
General Electric Co., Schenectady, N. Y.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

HOISTS, PORTABLE
Ingersoll-Rand Co., 11 Broadway, New York City.
Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

HOISTS, DERRICK
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, GASOLINE
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, Room
S. Flory Mfg. Co., Bangor, Pa.
Vulcan Iron Works, Wilkes-Barre, Pa.

HOISTS, Room and Gathering
S. Flory Mfg. Co., Bangor, Pa.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

HOISTS, Scraper-Loader
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
S. Flory Mfg. Co., Bangor, Pa.
Ingersoll-Rand Co., 11 Broadway New York City.

HOISTS, Shaft, Electric
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, Shaft, Steam
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, Shaker Chute
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, Slope, Electric
S. Flory Mfg. Co., Bangor, Pa.

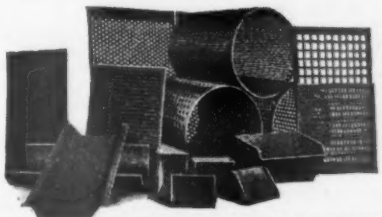
HOISTS, Slope, Steam
S. Flory Mfg. Co., Bangor, Pa.

HOISTS, STEAM
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Ingersoll-Rand Co., 11 Broadway, New York City.
Vulcan Iron Works, Wilkes-Barre, Pa.

HOLDERS-ON RIVETING
Ingersoll-Rand Co., 11 Broadway, New York City.

HOOKS
John A. Roebling's Sons Co., Trenton, N. J.

HOSE, AIR AND STEAM
Ingersoll-Rand Co., 11 Broadway, New York City.



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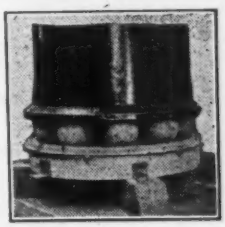

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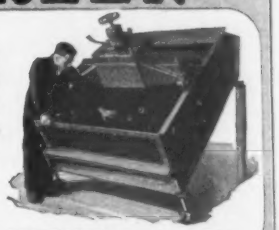

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WESTERN DIVISION MEETING

The annual meeting of the Western Division of The American Mining Congress will be held in Los Angeles the week of September 10.

For further information turn to page 572

PLAN TO BE THERE

HOSE, WELDING AND CUTTING
Oxweld Acetylene Co., 30 E. 42d St., New York City.

HYDRATORS, LIME
Vulcan Iron Works, Wilkes-Barre, Pa.

IGNITERS, Electric
Hercules Powder Co., Wilmington, Del.

INCINERATORS
Vulcan Iron Works, Wilkes-Barre, Pa.

INCLINE FROGS
Central Frog & Switch Co., Cincinnati, Ohio.

INCLINE TRACK LAYOUTS
Central Frog & Switch Co., Cincinnati, Ohio.

INDIVIDUAL SHOT-FIRING BATTERY
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

INSULATORS, FEEDER WIRE
General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

INSULATORS, SECTION
Amer. Mine Door Co., Canton, Ohio.
General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

INSULATORS (Porcelain)
General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

INSULATORS (Third Rail)
General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, Ohio.

INSULATORS (Trolley)
General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

INSULATED WIRE AND CABLE
American Steel & Wire Co., Chicago, Ill.
General Electric Co., Schenectady, N. Y.
John A. Roebling Sons Co., Trenton, N. J.

KEROSENE
Standard Oil Co. (Ind.), Chicago, Ill.

KEYSTONE DRILLS
Keystone Churn Drill Co., Beaver Falls, Pa.

KEYSTONE EXCAVATORS
Keystone Churn Drill Co., Beaver Falls, Pa.

KILNS (Rotary)
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Vulcan Iron Works, Wilkes-Barre, Pa.

KILNS, VERTICAL
Vulcan Iron Works, Wilkes-Barre, Pa.

LAMP CORD
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

LAMPS, ARC AND INCANDESCENT
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

LAMPS (Edison Electric)
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

LEAD BURNING APPARATUS, Oxy-Acetylene, Oxy-City Gas
Oxweld Acetylene Co., 30 E. 42d St., New York City.

LIGHT AND POWER PLANTS (Small)
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

LIGHT STEEL ANGLES
Sweet's Steel Co., Williamsport, Pa.
Carnegie Steel Co., Pittsburgh, Pa.

LIGHT STEEL RAILS
Carnegie Steel Co., Pittsburgh, Pa.
West Virginia Rail Co., Huntington, W. Va.

LIGHT STEEL RAILS (A. S. C. E. Sections)
Sweet's Steel Co., Williamsport, Pa.

LINE SHAFT
S K F Industries, 40 E. 34th St., New York City.

LOADERS, Gravel and Sand
Joy Manufacturing Co., Franklin, Pa.

LOADERS (Mine Car)
The Coloder Co., Columbus, Ohio.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Joy Manufacturing Co., Franklin, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Myers-Whaley Co., Knoxville, Tenn.

LOADERS, PORTABLE
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Joy Manufacturing Co., Franklin Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Myers-Whaley Co., Knoxville, Tenn.

LOADERS, Snow
Joy Manufacturing Co., Franklin Pa.

LOADERS, Truck
Joy Manufacturing Co., Franklin Pa.

LOADERS, Wagon
Joy Manufacturing Co., Franklin, Pa.

LOADING BOOMS
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.

LOADING MACHINES
The Coloder Co., Columbus, Ohio.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Myers-Whaley Co., Knoxville, Tenn.

LOCOMOTIVES, ELECTRIC
General Electric Co., Schenectady, N. Y.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

LOCOMOTIVES, GASOLINE
Vulcan Iron Works, Wilkes-Barre, Pa.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

LOCOMOTIVES, RACK RAIL
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

LOCOMOTIVES, STEAM
Vulcan Iron Works, Wilkes-Barre, Pa.

LOCOMOTIVES, STORAGE BATTERY
General Electric Co., Schenectady, N. Y.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Vulcan Iron Works, Wilkes-Barre, Pa.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

LOCOMOTIVE SWITCHING & WRECKING ROPES
John A. Roebling's Sons Co., Trenton, N. J.

LOCOMOTIVES (Third Rail)
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

LOCOMOTIVES, TROLLEY
General Electric Co., Schenectady, N. Y.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

LONGWALL MACHINES
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

LUBRICANTS
Keystone Lubricating Co., Philadelphia, Pa.
Standard Oil Co. (Ind.), Chicago, Ill.

LUBRICATORS
Keystone Lubricating Co., Philadelphia, Pa.

MACHINE OILS
Standard Oil Co. (Ind.), Chicago, Ill.

MACHINERY, TRANSMISSION (Power)
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y..

MANIFOLDS, OXYGEN
Oxweld Acetylene Co., 30 E. 42d St., New York City.

MAST ARM ROPE, Galvanized
John A. Roebling's Sons Co., Trenton, N. J.

METHANE RECORDER, CONTINUOUS
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

MILL GREASES
Standard Oil Co. (Ind.), Chicago, Ill.

MILLS, ROD & BALL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.

MILLS, STAMPS
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American Car & Foundry Co., 30 Church St., New York City.
Hockensmith Wheel & Mine Car Co., Penn, Pa.

MINE CAR BEARINGS
Hyatt Roller Bearing Co., Newark, N. J.
Timken Roller Bearing Co., Canton, Ohio.

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American Car & Foundry Co., 30 Church St., New York City.
Hockensmith Wheel & Mine Car Co., Penn, Pa.

MINE CAR FORGINGS
American Car & Foundry Co., 30 Church St., New York City.
Hockensmith Wheel & Mine Car Co., Penn, Pa.

MINE CAR LUBRICANTS
Keystone Lubricating Co., Philadelphia, Pa.
Standard Oil Co. (Ind.), Chicago, Ill.

MINE CAR PARTS
American Car & Foundry Co., 30 Church St., New York City.
Hockensmith Wheel & Mine Car Co., Penn, Pa.
Phillips Mine & Mill Supply Co., Pittsburgh, Pa.

MINE CAR ROLLER BEARINGS
American Car & Foundry Co., 30 Church St., New York City.

MINE CARS
American Car & Foundry Co., 30 Church St., New York City.
Enterprise Wheel & Car Corporation, Huntington, W. Va.
Hockensmith Wheel & Mine Car Co., Penn, Pa.
Phillips Mine & Mill Supply Co., Pittsburgh, Pa.

MINE CAR WHEELS
American Car & Foundry Co., 30 Church St., New York City.
Hockensmith Wheel & Mine Car Co., Penn, Pa.

MINE DOORS, AUTOMATIC
American Mine Door Co., Canton, Ohio.

MINE LOCOMOTIVE CABLE
American Steel & Wire Co., Chicago, Ill., and New York.
General Electric Co., Schenectady, N. Y.
John A. Roebling's Sons Co., Trenton, N. J.

MINE TIES
Central Frog & Switch Co., Cincinnati, Ohio.

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Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

MINING EQUIPMENT
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

MINING MACHINE CABLE
General Electric Co., Schenectady, N. Y.
John A. Roebling's Sons Co., Trenton, N. J.

MINING MACHINES
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

MINING MACHINES (Electric)
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

MINING MACHINES (Government Approved)
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.

MINING MACHINERY
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Ingersoll-Rand Co., 11 Broadway, New York City.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

MINING MACHINERY BEARINGS
Hyatt Roller Bearing Co., Newark, N. J.

MINING SPECIALTIES
G. R. Delamater, 3233 Chadbourne Road, Cleveland, Ohio.

MOTOR OILS
Standard Oil Co. (Ind.), Chicago, Ill.

MOTORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
General Electric Co., Schenectady, N. Y.
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

MOTORS, Electric
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

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Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

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American Steel & Wire Co., Chicago, Ill., and New York.
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Linde Air Products Co., 30 East 42d St., New York City.

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ORE, CARNOTITE & VANADIUM
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Hercules Powder Co., Wilmington, Del.

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A. M. Byers Co., Pittsburgh, Pa.

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Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.

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PNEUMATIC SIZING MACHINERY
American Coal Cleaning Corp., Welch, W. Va.

PNEUMATIC TOOL
Ingersoll-Rand Co., 11 Broadway, New York City.

PNEUMATIC TOOL LUBRICANT
Standard Oil Co. (Ind.), Chicago, Ill.

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Central Frog & Switch Co., Cincinnati, Ohio.

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Central Frog & Switch Co., Cincinnati, Ohio.

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The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

PREHEATING APPARATUS
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United Wood Treating Corp., 1138 Lake Shore Drive, Chicago, Ill.

PRESERVATIVES, WOOD
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Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works), 11 Broadway, New York City.
Keystone Churn Drill Co., Beaver Falls, Pa.

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Keystone Churn Drill Co., Beaver Falls, Pa.

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Ingersoll-Rand Co., 11 Broadway, New York City.

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PUMPS, Inclined Shaft
Ingersoll-Rand Co., 11 Broadway, New York City.

PUMPS, MINE
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Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works), 11 Broadway, New York City.

PUMPS, Sinking
Ingersoll-Rand Co., 11 Broadway, New York City.

PUMPS, PNEUMATIC AIR LIFT
Ingersoll-Rand Co., 11 Broadway, New York City.

PUMPS, POWER
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
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PUMPS, SAND
Ingersoll-Rand Co. (A. S. Cameron Steam Pump Works), 11 Broadway, New York City.

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PUNCHES, Drill Steel
Ingersoll-Rand Co., 11 Broadway, New York City.

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Central Frog & Switch Co., Cincinnati, Ohio.

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General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

RAMMERS, Pneumatic
Ingersoll-Rand Co., 11 Broadway, New York City.

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Ingersoll-Rand Co., 11 Broadway, New York City.

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Oxweld Acetylene Co., 30 E. 42d St., New York City.

REHEATERS, Air
Ingersoll-Rand Co., 11 Broadway, New York City.

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RESCUE APPARATUS
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RETARDERS
Mining Safety Device Co., Bowerston, Ohio.
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Mining Safety Device Co., Bowerston, Ohio.
Phillips Mine & Mill Supply Co., Pittsburgh, Pa.
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Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.

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Hercules Powder Co., Wilmington, Del.

SAND DRYERS
Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.

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John A. Roebling's Sons Co., Trenton, N. J.

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Ingersoll-Rand Co., 11 Broadway, New York City.

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Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

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American Coal Cleaning Corpn., Welch, W. Va.

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Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.

SCREENS, PERFORATED METAL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Hendrick Mfg. Co., Carbondale, Pa.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

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Hendrick Mfg. Co., Carbondale, Pa.
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Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

SCREENS, SHAKER
Hendrick Mfg. Co., Carbondale, Pa.
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Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
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Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

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Sullivan Machinery Co., 122 S. Mich. Ave., Chicago, Ill.

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John A. Roebling's Sons Co., Trenton, N. J.
Vulcan Iron Works, Wilkes-Barre, Pa.

SHEAVE WHEELS
Diamond Machine Co., Monongahela, Pa.
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SHORTWALL MACHINES
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Hyatt Roller Bearing Co., Newark, N. J.

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Myers-Whaley Co., Knoxville, Tenn.

SHOVEL—ELECTRO-HYDRAULIC
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

SIGNAL WIRES AND CABLES
American Steel & Wire Co., Chicago, Ill., and New York.
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John A. Roebling's Sons Co., Trenton, N. J.

SIGNS
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

SIGNS (Mine)
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Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Connellsville Mfg. & Mine Supply Co., Connellsville, Pa.
Hendrick Mfg. Co., Carbondale, Pa.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.
Vulcan Iron Works, Wilkes-Barre, Pa.

SKIP LOADING EQUIPMENT
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.

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Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.

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Morse Chain Co., Ithaca, N. Y.

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Morse Chain Co., Ithaca, N. Y.

SPIKES
Sweet's Steel Co., Williamsport, Pa.
West Virginia Rail Co., Huntington, W. Va.

SPLICE BARS (Plain and Angle)
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Central Frog & Switch Co., Cincinnati, Ohio.
Sweet's Steel Co., Williamsport, Pa.
West Virginia Rail Co., Huntington, W. Va.

SPLICE, CABLE
American Mine Door Co., Canton, Ohio.
Ohio Brass Co., Mansfield, Ohio.

SPLICE, INSULATOR
American Mine Door Co., Canton, Ohio.

SPLICE, TROLLEY WIRE
General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, Ohio.

SPLICERS, TROLLEY
American Mine Door Co., Canton, Ohio.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

SPROCKETS, CLAMP HUB
Morse Chain Co., Ithaca, N. Y.

SPROCKETS, COMPENSATING
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

SPROCKETS (Shearing Pin)
Morse Chain Co., Ithaca, N. Y.

SPROCKETS, SILENT CHAIN
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

SPROCKETS, SPRING
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

SPUR GEAR DRIVES
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

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John A. Roebling's Sons Co., Trenton, N. J.

STEAM CYLINDER OILS
Standard Oil Co. (Ind.), Chicago, Ill.

STEEL, ALLOY
Timken Roller Bearing Co., Canton, Ohio.

STEEL CROSS TIES
Carnegie Steel Co., Pittsburgh, Pa.
Sweet's Steel Co., Williamsport, Pa.
West Virginia Rail Co., Huntington, W. Va.

STEEL, ELECTRIC FURNACE
Timken Roller Bearing Co., Canton, Ohio.

STEEL, HOLLOW AND SOLID DRILL
Ingersoll-Rand Co., 11 Broadway, New York City.

STEEL, NICKEL
Timken Roller Bearing Co., Canton, Ohio.

STEEL, NICKEL, MOLYBDENUM
Timken Roller Bearing Co., Canton, Ohio.

STEEL, OPEN HEARTH
Timken Roller Bearing Co., Canton, Ohio.

STEEL, REINFORCING
American Mine Door Co., Canton, Ohio.

STEEL, SHAPES, PLATES, BARS, ETC.
Carnegie Steel Co., Pittsburgh, Pa.

STEEL, Special Analysis
Timken Roller Bearing Co., Canton, Ohio.

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Carnegie Steel Co., Pittsburgh, Pa.
West Virginia Rail Co., Huntington, W. Va.

STEPS, SAFETY STAIR AND LADDER
Hendrick Mfg. Co., Carbondale, Pa.

STOPERS, ROCK DRILL
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Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
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Vulcan Iron Works, Wilkes-Barre, Pa.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

STRAND
American Steel & Wire Co., Chicago, Ill., and New York.
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SWITCHBOARD WIRE AND CABLES
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

SWITCHBOARDS, POWER
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

SWITCHES
Central Frog & Switch Co., Cincinnati, Ohio.
Sweet's Steel Co., Williamsport, Pa.

SWITCHES, ALTERNATING
Mining Safety Device Co., Bowerston, Ohio.

SWITCHES (Disconnecting and Electric)
General Electric Co., Schenectady, N. Y.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

SWITCHES AND FROGS, TROLLEY
American Mine Door Co., Canton, Ohio.
Central Frog & Switch Co., Cincinnati, Ohio.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

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John A. Roebling's Sons Co., Trenton, N. J.

TANKS
Hendrick Mfg. Co., Carbondale, Pa.

TELEGRAPH AND TELEPHONE WIRES AND CABLES
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John A. Roebling's Sons Co., Trenton, N. J.

TELEPHONE CORDS
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

THIMBLES
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

TIES (Steel, Mine)
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Central Frog & Switch Co., Cincinnati, Ohio.

TILLER ROPE
John A. Roebling's Sons Co., Trenton, N. J.

TIMBER PRESERVING EQUIPMENT
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Cr[illegible]n-Howe Corpn., 11 Park Place, New York City.
United Wood Treating Corp., 1138 Lake Shore Drive, Chicago, Ill.

TIMBERS, STEEL MINE
Carnegie Steel Co., Pittsburgh, Pa.

TIPPLES
American Coal Cleaning Corp., Welch, W. Va.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.

TIPPLE EQUIPMENT
American Coal Cleaning Corp., Welch, W. Va.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Mining Safety Device Co., Bowerston, Ohio.
Phillips Mine & Mill Supply Co., Pittsburgh, Pa.
Roberts & Schaefer Co., Wrigley Bldg., Chicago, Ill.

TIPPLE TRACK
Central Frog & Switch Co., Cincinnati, Ohio.

TIRE WIRES
John A. Roebling's Sons Co., Trenton, N. J.

TOOLS, Blacksmiths (for drill steel)
Ingersoll-Rand Co., 11 Broadway, New York City.

TOOLS AND SUPPLIES
Keystone Churn Drill Co., Beaver Falls, Pa.

TORCHES, Brazing, Carbon Burning, Cutting, Lead Burning, Welding, Welding and Cutting
Oxweld Acetylene Co., 30 E. 42d St., New York City

TRACK BOLTS
Sweet's Steel Co., Williamsport, Pa.

TRACK EQUIPMENT
Carnegie Steel Co., Pittsburgh, Pa.
Central Frog & Switch Co., Cincinnati, Ohio.
Sweet's Steel Co., Williamsport, Pa.
West Virginia Rail Co., Huntington, W. Va.

TRACK LAYOUTS (Industrial)
Central Frog & Switch Co., Cincinnati, Ohio.
Sweet's Steel Co., Williamsport, Pa.

TRACKS, PORTABLE, RAIL, ETC.
Carnegie Steel Co., Pittsburgh, Pa.
Central Frog & Switch Co., Cincinnati, Ohio.
West Virginia Rail Co., Huntington, W. Va.

TRACK (Portable)
Carnegie Steel Co., Pittsburgh, Pa.
Central Frog & Switch Co., Cincinnati, Ohio.
Sweet's Steel Co., Williamsport, Pa.

TRACK (Portable, Assembled and Unassembled, Riveted or Bolted)
Carnegie Steel Co., Pittsburgh, Pa.
Central Frog & Switch Co., Cincinnati, Ohio.
West Virginia Rail Co., Huntington, W. Va.

TRACK BRACES
Central Frog & Switch Co., Cincinnati, Ohio.

TRACK SUPPLIES
Carnegie Steel Co., Pittsburgh, Pa.
Central Frog & Switch Co., Cincinnati, Ohio.
West Virginia Rail Co., Huntington, W. Va.

TRAMWAYS, AERIAL
American Steel & Wire Co., Chicago, Ill., and New York.

TRANSFORMER OILS
Standard Oil Co. (Ind.), Chicago, Ill.

TRANSFORMERS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

TRANSMISSION
S K F Industries, 40 E. 34th St., New York City.

TRANSMISSION OILS AND GREASES
Standard Oil Co. (Ind.), Chicago, Ill.

TRANSMISSION, SILENT CHAIN
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

TREADS, SAFETY STAIR AND LADDER
Hendrick Mfg. Co., Carbondale, Pa.

TRIP LAMPS
Mine Safety Appliances Co., Braddock Ave. and Thomas Blvd., Pittsburgh, Pa.

TROLLEY FROGS
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

TROLLEY (Hangers and Clamps)
General Electric Co., Schenectady, N. Y.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

TROLLEY MATERIAL, OVERHEAD
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

TROLLEY WHEELS AND HARPS
Goodman Mfg. Co., Halsted St. and 48th Place, Chicago, Ill.
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Ohio Brass Co., Mansfield, Ohio.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

TROLLEY WIRE
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

TRUCKS, WELDER'S
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

TURBINE BLOWERS
Robinson Ventilating Co., Zelienople, Pa.

TURBINES, HYDRAULIC
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Standard Oil Co. (Ind.), Chicago, Ill.

TURBINES, STEAM
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

TURNBUCKLES
American Steel & Wire Co., Chicago, Ill., and New York.
John A. Roebling's Sons Co., Trenton, N. J.

TURNOUTS
Sweet's Steel Co., Williamsport, Pa.

VALVES
Ohio Brass Co., Mansfield, Ohio.

VALVES, Back Pressure, Pressure Reducing
Oxweld Acetylene Co., 30 E. 42nd St., New York City.

VANADIUM ORE
O. Barlow Willmarth, Georgetown, Ohio.

VENTILATING EQUIPMENT
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Robinson Ventilating Co., Zelienople, Pa.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

VISES, Riggers
John A. Roebling's Sons Co., Trenton, N. J.

WAGON LOADERS
The Jeffrey Mfg. Company, 958-99 North 4th St., Columbus, Ohio.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.

WASHERIES
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Coal Cleaning Corp., Welch, W. Va.
Link-Belt Co., 300 W. Pershing Rd., Chicago, Ill.
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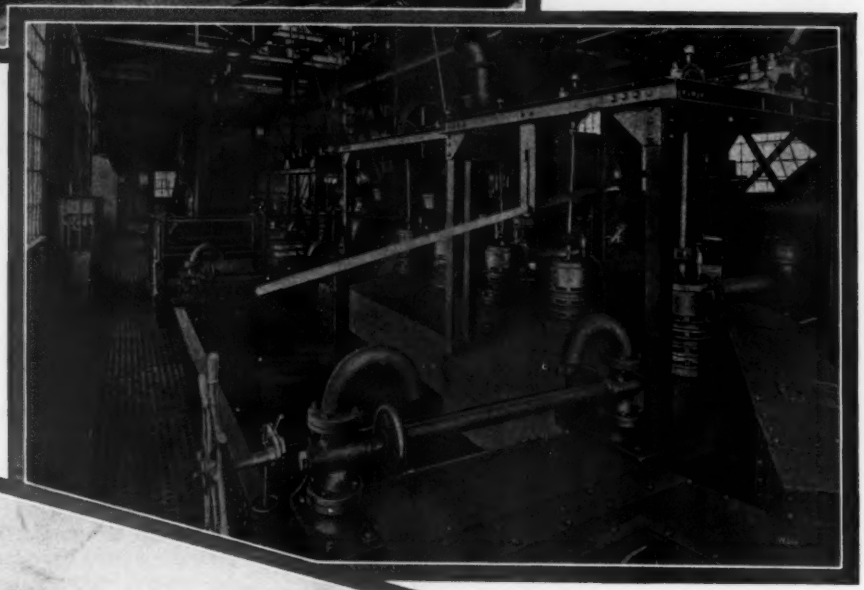

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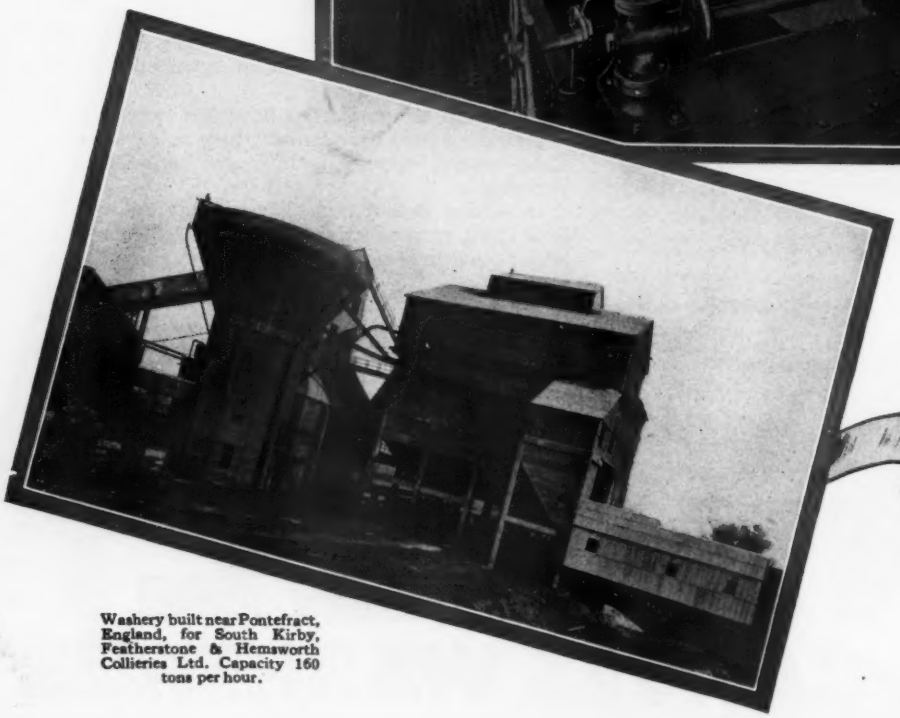

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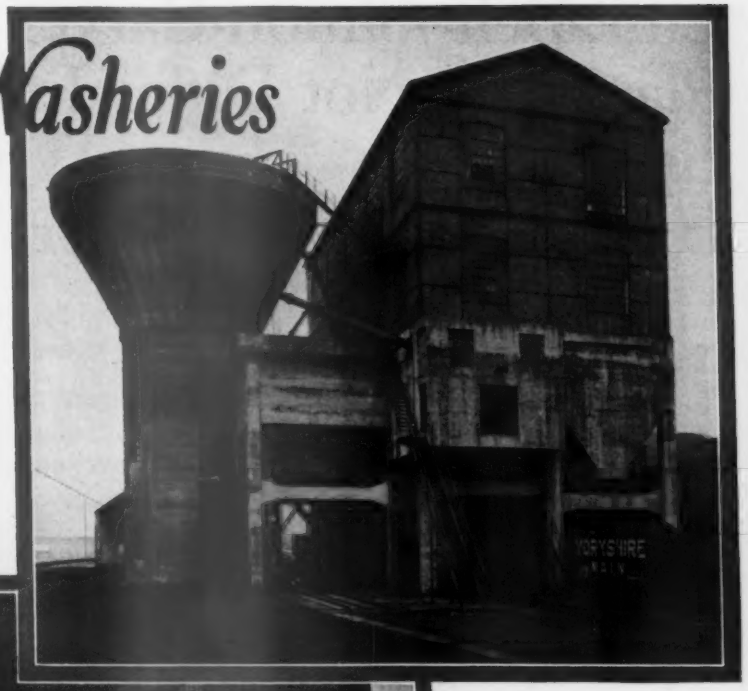

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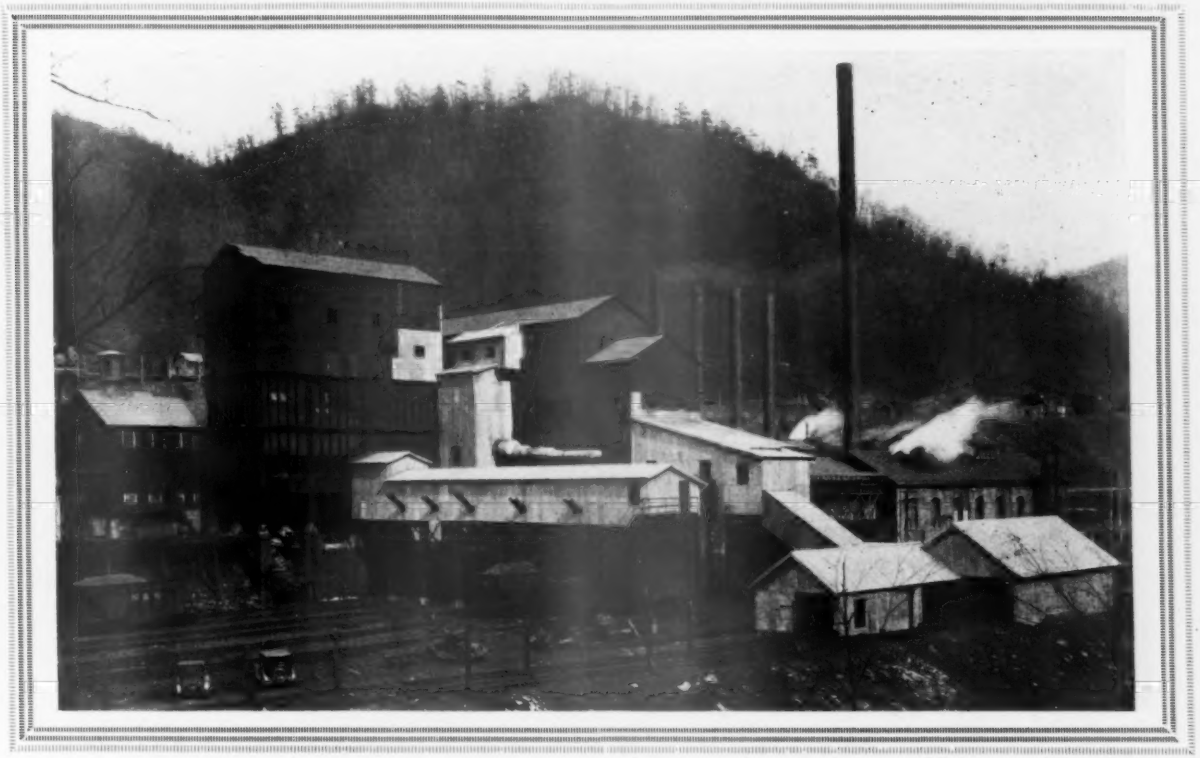

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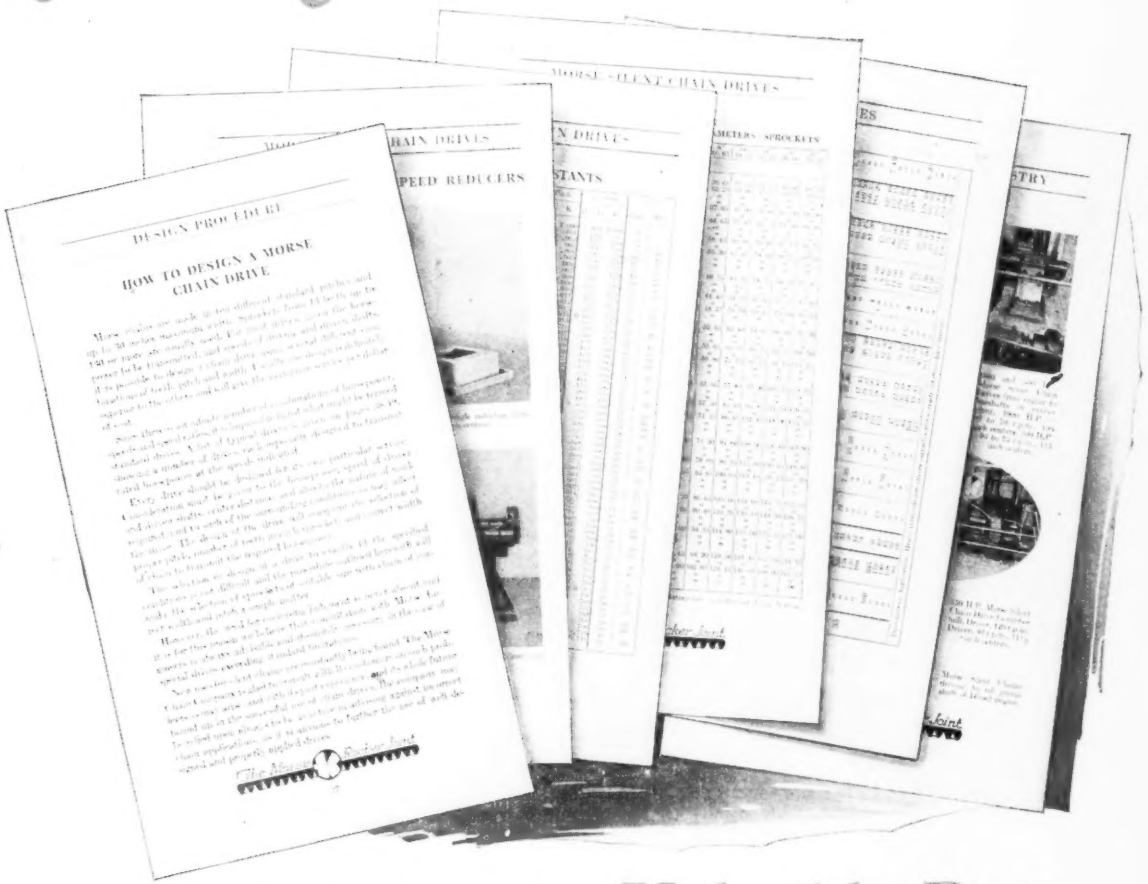

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